SM-ALR Monitoring

M25 J23-27 Second Year Evaluation Report

Highways England

March 2017

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Table of contents

Tables

Figures

Executive summary

Background

Expanding evidence base to provide ongoing confidence

Smart motorways are a technology-driven approach to the use of our motorways. They increase capacity and improve journey time reliability while maintaining safety.

The Smart Motorway All Lane Running (SM-ALR) scheme, M25 J23 to J27, has previously been monitored and evaluated for a one year After period. The evidence base is being continually expanded, providing ongoing confidence in the ALR concept. Atkins was therefore commissioned to perform a wide-ranging, comprehensive evaluation of the second year of operation. It is crucial that the performance of the scheme is accurately assessed in order to:

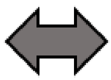
- review the safety performance during the initial period of operation;
- continue to monitor and understand the change in risk to road users and to road workers;
- quantify and provide evidence of the benefits of the concept; and
- provide evidence to help improve the concept of operation and the design requirements.

This report presents the results following the second year of After evaluation from May 2015 to April 2016. It is split into sections to cover each of the objectives of SM-ALR assessed in this report:

SM-ALR objectives

- flows;
- journey times; and
- safety.

Overview of Year 2 Results compared to Before Period

M25 J23-J27		
Flows	J23-6: Significant (10%) flow increase achieved and capacity for more growth In particular 17% J24-25 CW. All higher than national trends.	
Average journey time	JTs returned close to pre-scheme levels but have been worse if scheme not built. CW 3% increase overall, ACW 0.5% decrease.	
Journey time reliability	Slight improvement day-to-day on both carriageways	
Safety	No significant change after taking into account background trends. Scheme has met its safety objectives.	

Flows

Flow has increased between 6,000 and 11,000 vehicles per day, significantly above national trends

Between J23 and J26, average daily flows have increased in excess of 10% on all links. J24 to J25 has seen 17% increase for clockwise flow and 12% for anticlockwise. All links have increased at a higher rate than national trends. No data was available for J26 to J27.

The results demonstrate that significant capacity improvements have been achieved, supporting efficient movement of goods and services on this key section of the SRN; in addition there is still spare capacity to support future growth.

Journey Times

Clockwise some journey times have increased, but would be worse without the scheme

Clockwise, the average journey time to traverse the scheme has increased by 3% compared to before, which equates to 26 seconds additional journey time per vehicle. Monday to Thursday AM peaks have seen the largest increase of 8%. The journey time increase in the second year of operation is probably related to the increase in flow and appears to be mainly due to congestion at the J25 roundabout; this is currently being upgraded. It should be noted that if the scheme had not been built, journey times would almost certainly have deteriorated further, without the significant extra capacity being achieved.

Anticlockwise journey times are improved

Anticlockwise there is a 0.5% improvement in journey time to traverse the scheme, which equates to a journey time saving of 5 seconds per vehicle; effectively no change in average journey times. The Monday to Thursday PM peak has the largest journey time saving of 5%.Again, journey times have increased in the second year as the flows have increased and are now close to pre-scheme levels.

Journey time reliability has improved slightly

There has been a slight improvement day to day in journey time variability in the most congested periods on both carriageways, demonstrating that journey times are now more reliable. Some other periods have seen a slight increase but overall there is a slight improvement in reliability while flows have increased more than 10%.

Safety

The scheme has achieved its safety objective

The collision rate has reduced by 11% overall, representing a 1% increase after taking into account the national trend between periods; this is not statistically significant and should be considered as 'no significant change'. This suggests that the scheme is achieving its objective of maintaining safety performance, although further monitoring is required due to the small sample size.

FWI rate and KSI rate reduced, but these results are based on a small sample size, so no conclusions should be drawn.

No collisions were reported involving road workers on ALR.

Compliance with Red X signals was observed on average to be 96% of the total flow on the carriageway during the lane closure. This is an improvement on 93% in the first year of operation.

82% of ERA stops not an emergency

During ERA monitoring one stop every 2 hours per ERA was observed. Non-emergency use was judged to be 82%. In 3% of all stops the ERT was used and in 7% of all stops a Highways England Traffic Officer attended. Other ERA observations were:

- no instances of problems with ERA operation were observed; and
- no collisions relating to vehicles exiting ERAs.

1. Introduction

1.1. Scope of project and purpose of this report

Having completed the monitoring and evaluation of the first year of operation, Highways England commissioned this project to monitor and evaluate the impact following the second year's operation of the first SM-ALR scheme, M25 Junction 23 to Junction 27. The evidence base is being continually expanded, providing ongoing confidence in the ALR concept. It is crucial that the performance of the scheme is accurately assessed for a second year of operation in order to:

- review the safety performance during the initial period of operation;
- continue to monitor and understand the change in risk to road users and to road workers;
- quantify and provide evidence of the benefits of the concept; and
- provide evidence to help improve the concept of operation and the design requirements.

As part of the previous SM-ALR Monitoring project, an evaluation methodology was designed. The analysis for the Before period and both Yr1 After and Yr2 After follows this methodology to ensure that all results are comparable.

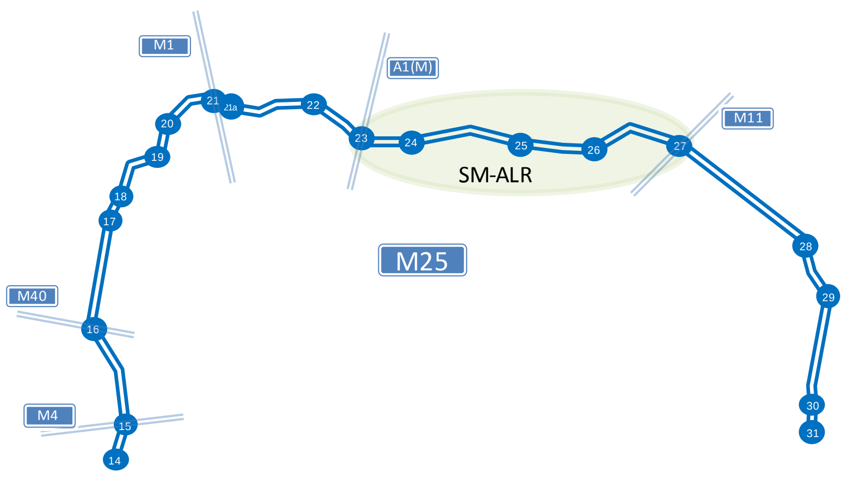
The report is split into sections to cover each of the objectives of SM-ALR: flows, journey times and safety.

1.2. Background of the scheme

1.2.1. Location

The SM-ALR scheme, M25 J23 to J27, is part of the key strategic orbital route around London which forms the hub of the English motorway network; it is also a commuter route for local traffic. It lies within the counties of Hertfordshire, Essex and the Greater London Authority and is located in the northern segment of the M25. J23 is the intersection with the A1(M) and J27 the intersection with the M11.

Figure 1-1 Geographical location of the M25 J23 to J27 SM-ALR scheme



The SM-ALR scheme encompasses two tunnels, Holmesdale located between J25 and J26 and Bell Common between J26 and J27.

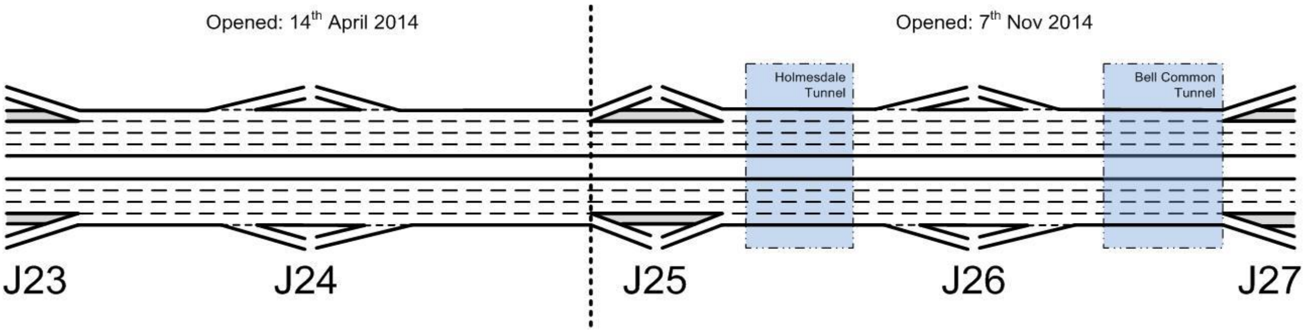
The majority of the M25 is Smart Motorway with hard shoulders which, together with the SM-ALR scheme, form an overall long term strategy to manage the existing motorway network more effectively.

1.2.2. The SM-ALR scheme

SM-ALR is a controlled four lane carriageway with no hard shoulder. This is supported by technology in the form of Motorway Incident Detection and Automatic Signalling (MIDAS) traffic detection and traffic control. The signs and signals can be controlled by operators and by automatic algorithms for Congestion Management (CM) and Queue Protection (QP). Emergency Refuge Areas (ERAs) are available for emergencies.

This scheme was opened in two stages, J23 to J25 opening in May 2014 and J25 to J27 opening in November 2014, see Figure 1-2.

Figure 1-2 M25 J23 to J27 SM-ALR scheme split



1.3. Evaluation timescales

This report presents the results of evaluation and monitoring following two years' operation of the scheme from May 2014 to April 2016. For clarity and efficiency, the evaluation periods will be referred to as follows throughout this report:

- Before - Baseline;
- Yr1 After - First year after opening;
- Yr2 After - Second year after opening; and
- After Period - Entire after period.

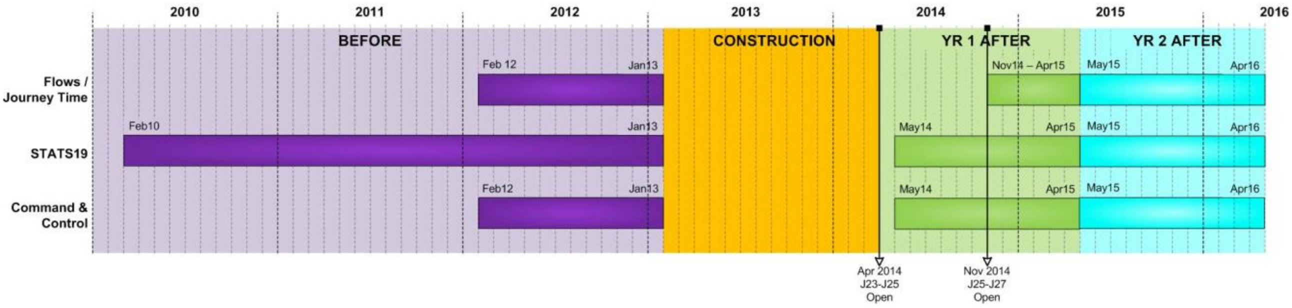
The evaluation makes comparisons between the Before and After periods, while monitoring has taken place during the After periods only. The monitoring results report compliance with Red X and ERA usage.

Figure 1-3 shows the evaluation periods used for the Before and After periods.

This scheme was opened in two stages, J23 to J25 opening in May 2014 and J25 to J27 opening in November 2014. Consequently, the After safety analysis of STATS19 data is based on the data for J23 to J25 only until November 2014.

The flow and journey time evaluations compare the Before with Yr2 After; the last 6 months of Yr1 After are not comparable due to the different duration so are not included in this evaluation. (The results for Before versus Yr1 After can be found in the First Year Evaluation report.) The monitoring results are presented only for Yr2 After and again, the Yr1 After results can be found in the first year report.

Figure 1-3 Data collection & evaluation periods



For the analysis of flows and journey times it is useful to consider the results separately for different day types and time slices. This is because the traffic conditions are different and therefore so are the impacts. Table 1-1 shows the time slices and day types used for the flow and journey time analysis, in accordance with the Monitoring Design Report.

Table 1-1 Day type and time slice definitions

Day type	AM peak	Inter-peak	PM peak
Monday – Thursday	05:30 – 10:30	10:30 – 15:00	15:00 – 20:00
Friday	05:00 – 09:00	09:00 – 13:00	13:00 – 20:00
Saturday - Sunday		08:00 – 20:00	

1.4. Expected effects of SM-ALR

The SM-ALR concept involves increasing the number of running lanes from three to four by re-allocating the space previously used by the hard shoulder. In addition, other infrastructure is provided to deliver a controlled environment to manage the risks associated with converting the hard shoulder to a traffic lane.

The effect of an increase in capacity is that periods of congestion are expected to be less frequent, shorter and less intense leading to reductions in journey time and better journey time reliability. The road effectively becomes more resilient to regular and incident related congestion.

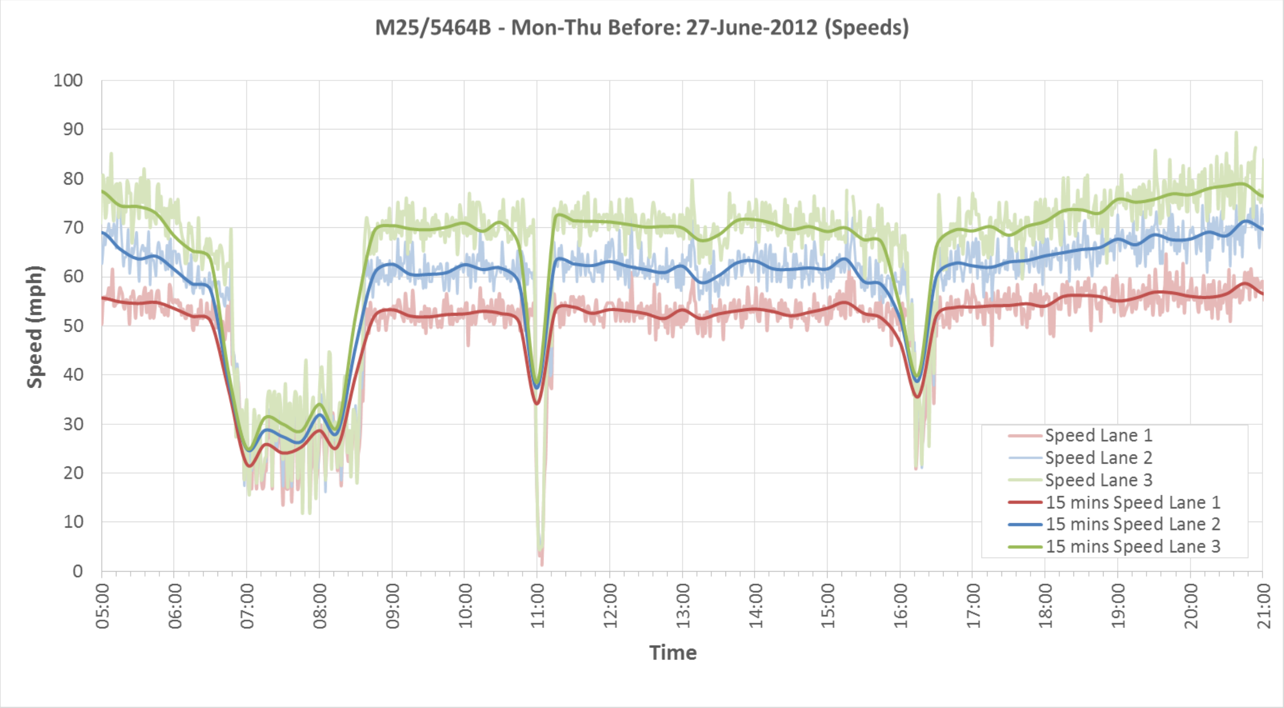
In addition safety benefits could be realised because traffic speeds become more consistent and the speed differential between lanes reduces. The number of unnecessary hard shoulder stops, which are inherently risky, should also be reduced.

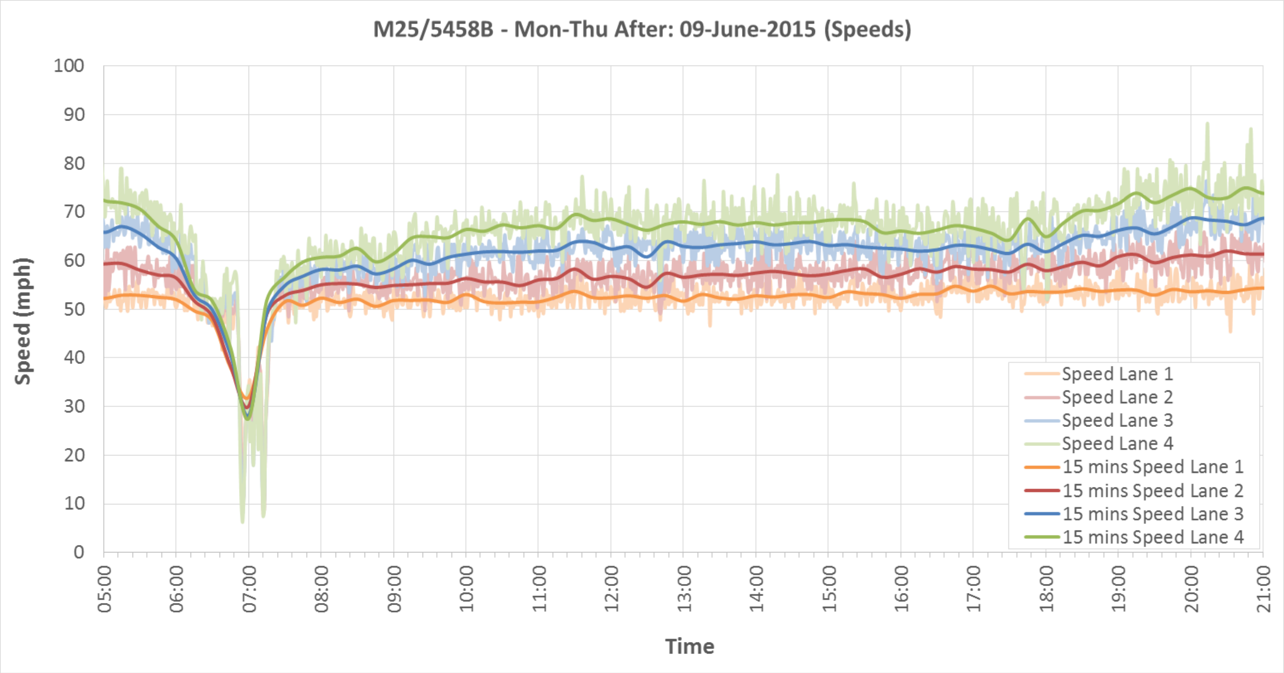
These effects can be seen by looking at traffic performance on a daily basis. The following subsections show speed by lane, flow by lane, speed distribution and speed flow curves for typical days in the before and Yr2 after periods. The plots show a snapshot of just one location and one day, to demonstrate the positive impacts.

1.4.1. Speed by lane

The effect on speeds has been positive as demonstrated by Figure 1-4, which shows a snapshot of data from Before and Yr2 After collected during the evaluation process. It can be seen that in the Before period, there was significant congestion in AM, PM and inter-peaks. Average offside lane speeds were above the national speed limit during uncongested times (up to 78mph at night) and there was a speed differential of approximately 10mph between lanes. The After snapshot shows congestion only in the AM peak, lasting for a shorter duration. The average offside lane speeds have reduced closer to the speed limit and the speed differential between lanes is also lower, in the order of 6mph.

Figure 1-4 Snapshot of speeds by lane Before and Yr2 After

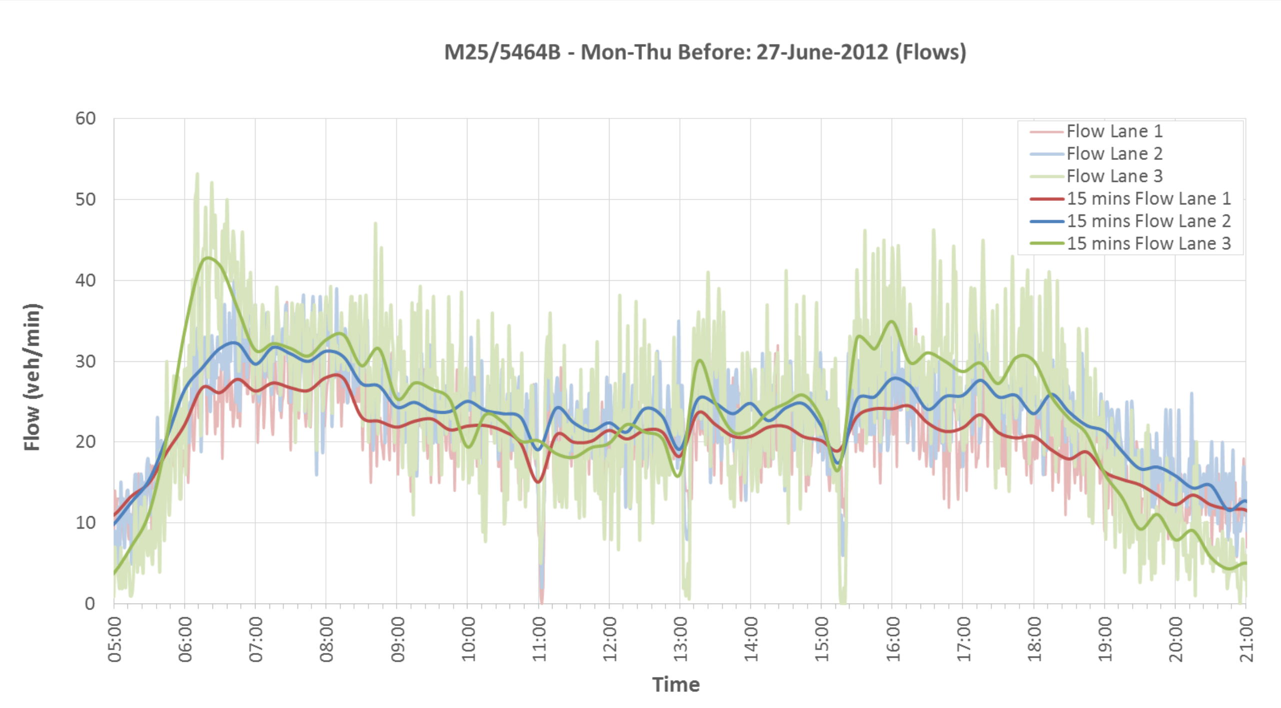


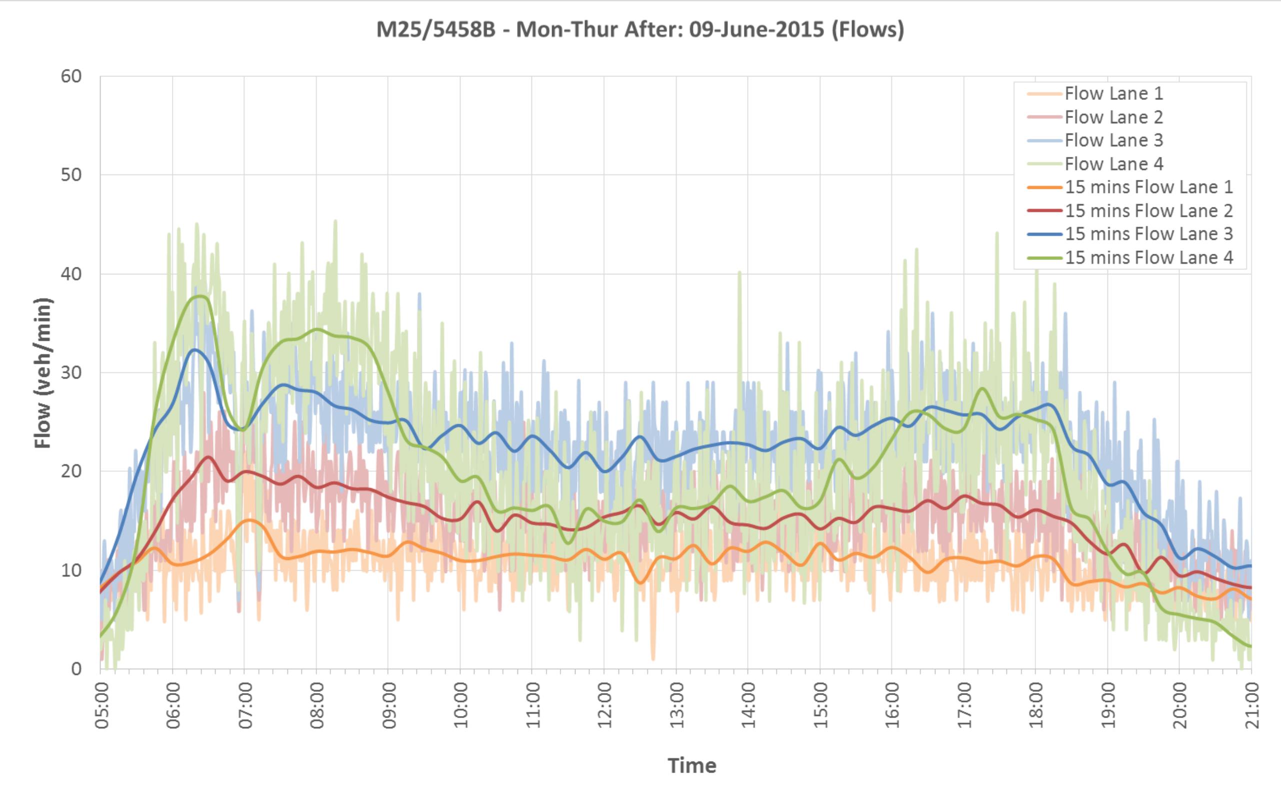


1.4.2. Flow by lane

Figure 1-5 shows the flow by lane for the Before and Yr2 After periods. In the Before, flows per lane are relatively similar for most of the day. The lane 3 flow is the highest in the peak periods and the lowest during the night.

Figure 1-5 Flow by lane Before and Yr2 After





It is notable that lane 1 flows are much lower than the other lanes in Yr2 After, indicating that drivers are less keen to use that lane; this effect is common when SM schemes are introduced. The lane gain, lane drop arrangement can make lane 1 less likely to be used; in addition drivers can be reluctant to use lane 1 as found in the road user surveys performed in the first year of operation.

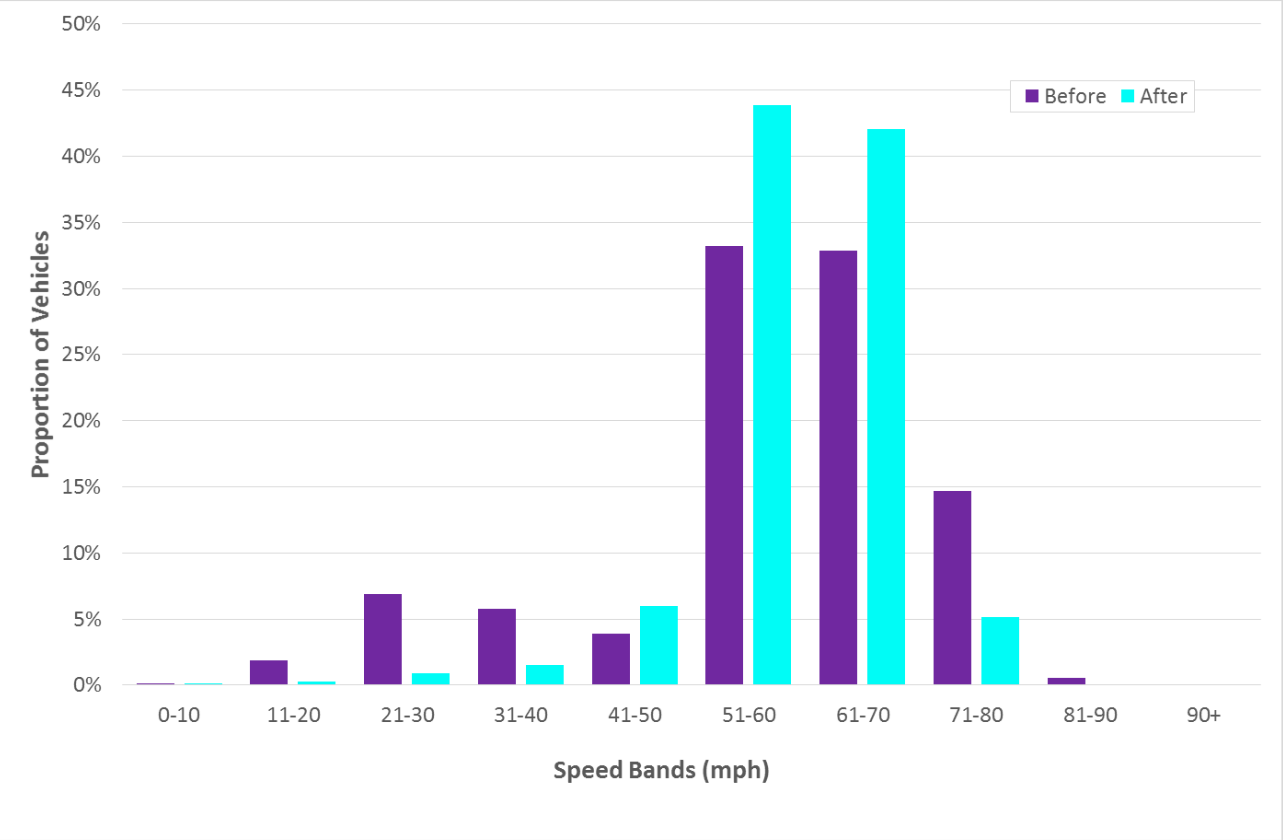
Another useful finding demonstrated by these graphs is that although total flow is higher, the peak flow per lane is lower in Yr2 After compared to the Before, this indicates that there is still some spare capacity for future growth.

1.4.3. Speed distribution

Figure 1-6 shows the approximate proportions[1] of vehicles travelling at speeds in different 10mph 'bands', over a 24 hour period in the Before and Yr2 After. The key points of interest are:

In the Yr2 After period, over 85% of vehicles were travelling between 51 and 70mph, compared to 65% in the Before. A larger proportion of vehicles were doing low speeds in the Before period due to greater levels of congestion. In addition, a greater proportion of vehicles exceeded the speed limit in the Before, including some doing over 81mph.

Figure 1-6 Speed distribution Before and Yr 2 After

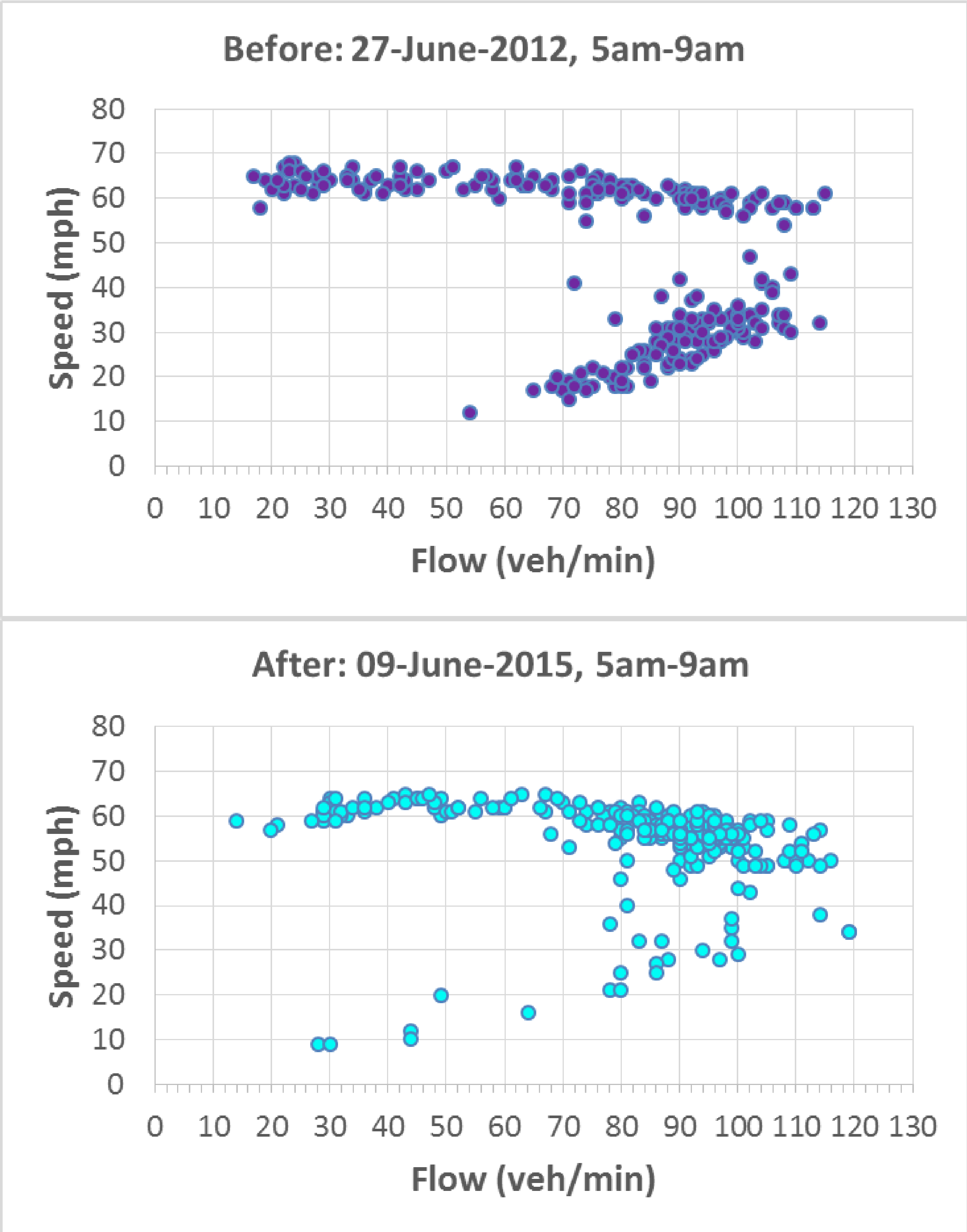


[1] TCD data has been used providing the average speed minutely per lane.

1.4.4. Speed flow curve

In the Before period it can be seen that traffic flow peaks at 115veh/min, before the flow breaks down causing congestion, while in the After Yr2 sample flows go up to 120veh/min with noticeably less severe flow breakdown.

Figure 1-7 Speed flow curves Before and Yr2 After



2. Flows

2.1. Introduction

This section presents the results of the traffic flow analysis for J23 to J26; it has not been possible to evaluate the flows between J26 and J27 due to issues with the traffic data. At the Yr1 After stage, no traffic data was presented for J25 to J27. Whilst it was envisaged that the quality of the available traffic data at the Yr2 After stage would have improved sufficiently to allow a full analysis, this has only been possible for J25 to J26 due to ongoing data quality issues between J26 and J27.

The traffic data has been taken from Highways England's MIDAS database. Similar data is available through the WebTRIS website, but at present the website does not present data for the section considered here.

The Yr2 After period covers the second year after opening, May 2015 – April 2016. The Yr1 After report covered the six months following the opening of Section 5b (J25 – J27); these results are not comparable with the 12 month sample so have not been included in this report.

2.1.1. Data availability and quality

Highways England and their suppliers are investigating a known issue with the quality of flow data from radar detectors and work is underway to improve it. Until the data quality improves, to overcome the variability between adjacent detectors during the evaluation period, data from all detector sites have been compared against publically available Manual Classified Counts (MCCs) to determine which sites can be considered to be more reliable. It was not possible to do this for J26 to J27 due to the lack of MCC data in the time period being evaluated, so no comparison has been performed for this link.

2.2. Daily flows per link

The average daily traffic for the Before and After periods is compared in Figure 2-1 to Figure 2-6, with the 24 hour Average Daily Traffic (ADT) flows between each junction plotted for the different day types. The percentage change is shown above the Yr2 After bar in each case. The corresponding values are shown in Appendix A.1.

Daily flows have increased in all day types in both directions.

In the clockwise direction, weekday flows have seen increases between 8% and 9% for Mon-Thu and Fri day types between J23 and J24 and between J25 and J26. The clockwise traffic flow between J24 and J25 is 14% and 13% for the Mon-Thu and Fri day types respectively. Whilst this cannot be directly compared to the traffic flow changes at the Yr1 After stage (as only six months of data was being considered) it should be noted that there was minimal increase in traffic between J24 and J25 at that stage. Traffic flow increases at the weekend are between 15% and 16% for J23 to J24 and J25 to J26; again a greater increase of 26% can be seen between J24 and J25.

In the anticlockwise direction, the largest traffic flow increase is again seen between J24 and J25 (at 11% for Mon-Thu and Fri day types) but the traffic flow increase between J25 and J26 is very similar at 10% for the corresponding day types. The traffic flow increase between J23 and J24 is slightly lower at 6% and 8% for the Mon-Thu and Fri day types respectively. Traffic flow increases at the weekend are again higher than for weekdays, with increases of between 14% and 18% being observed.

Figure 2-1 Average daily traffic by day type J23-J24 clockwise

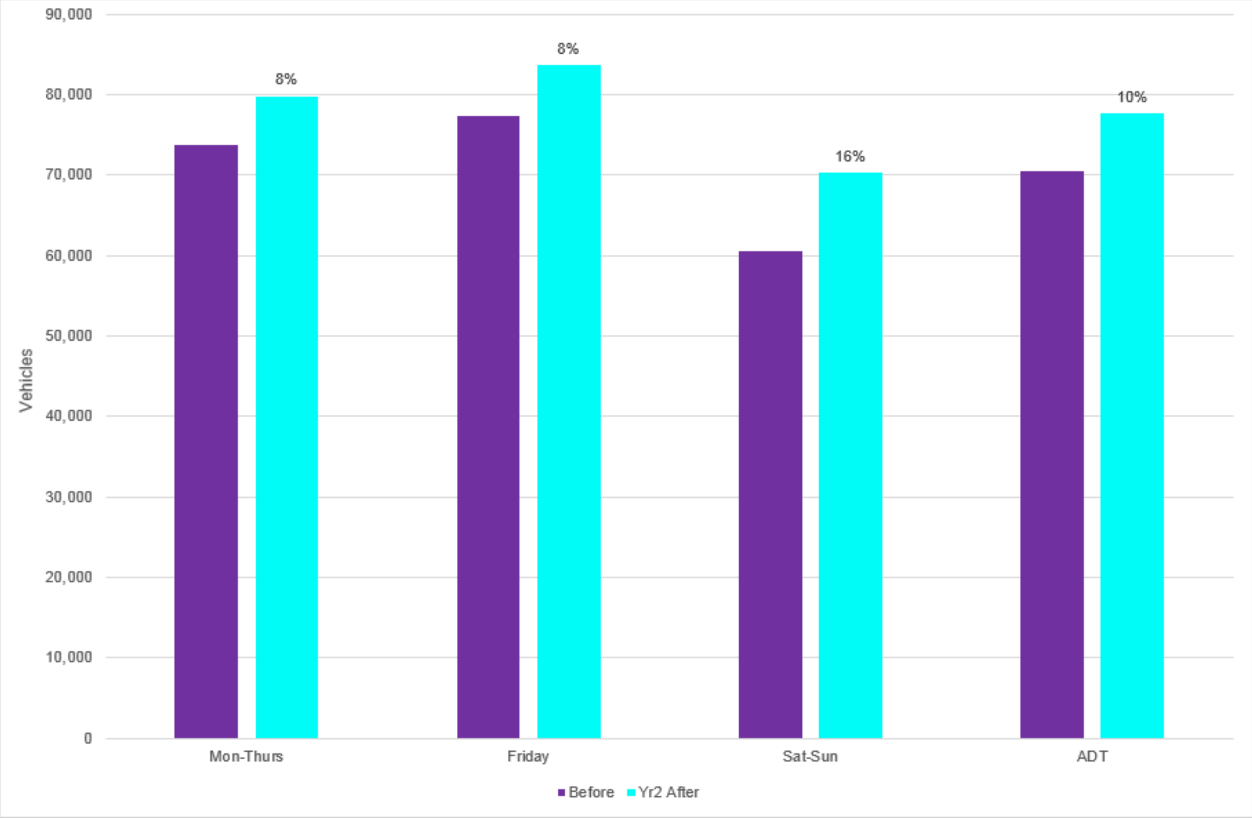


Figure 2-2 Average daily traffic by day type J24-J25 clockwise

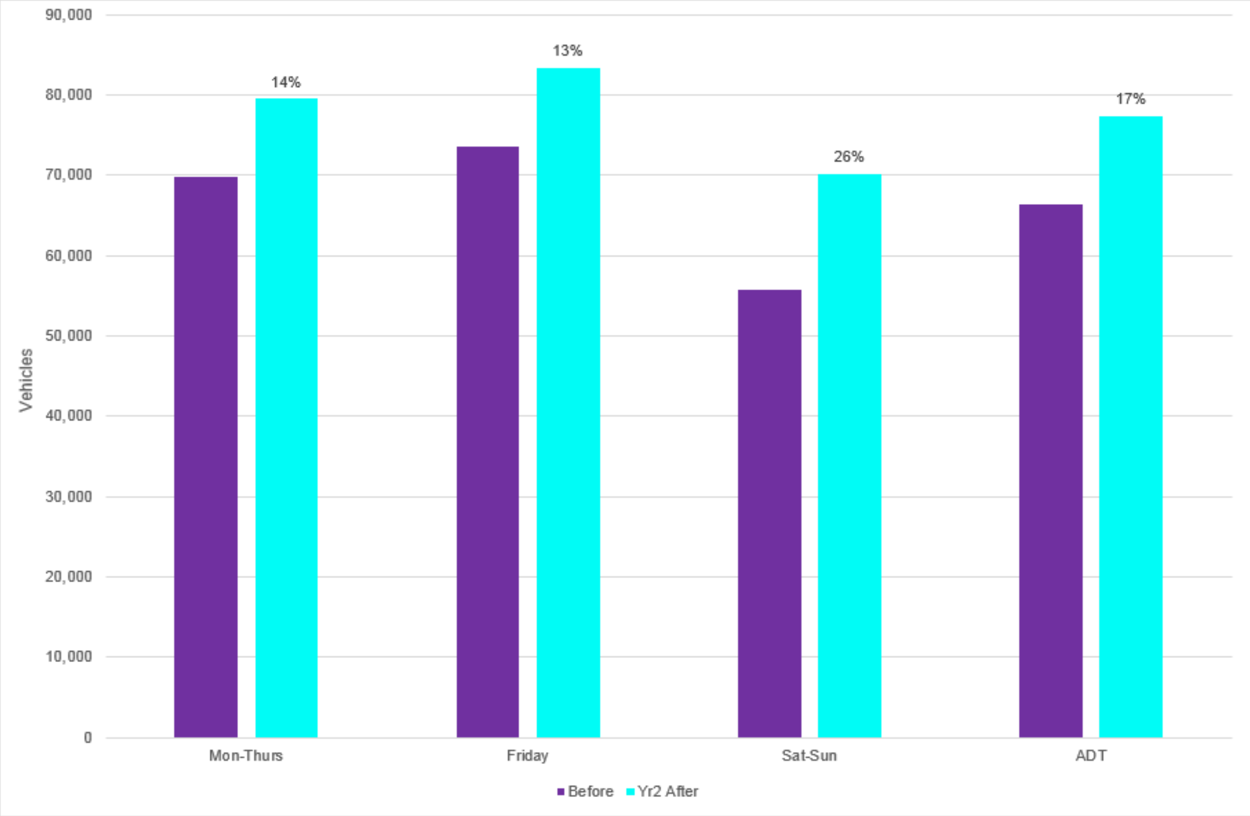


Figure 2-3 Average daily traffic by day type J25-J26 clockwise

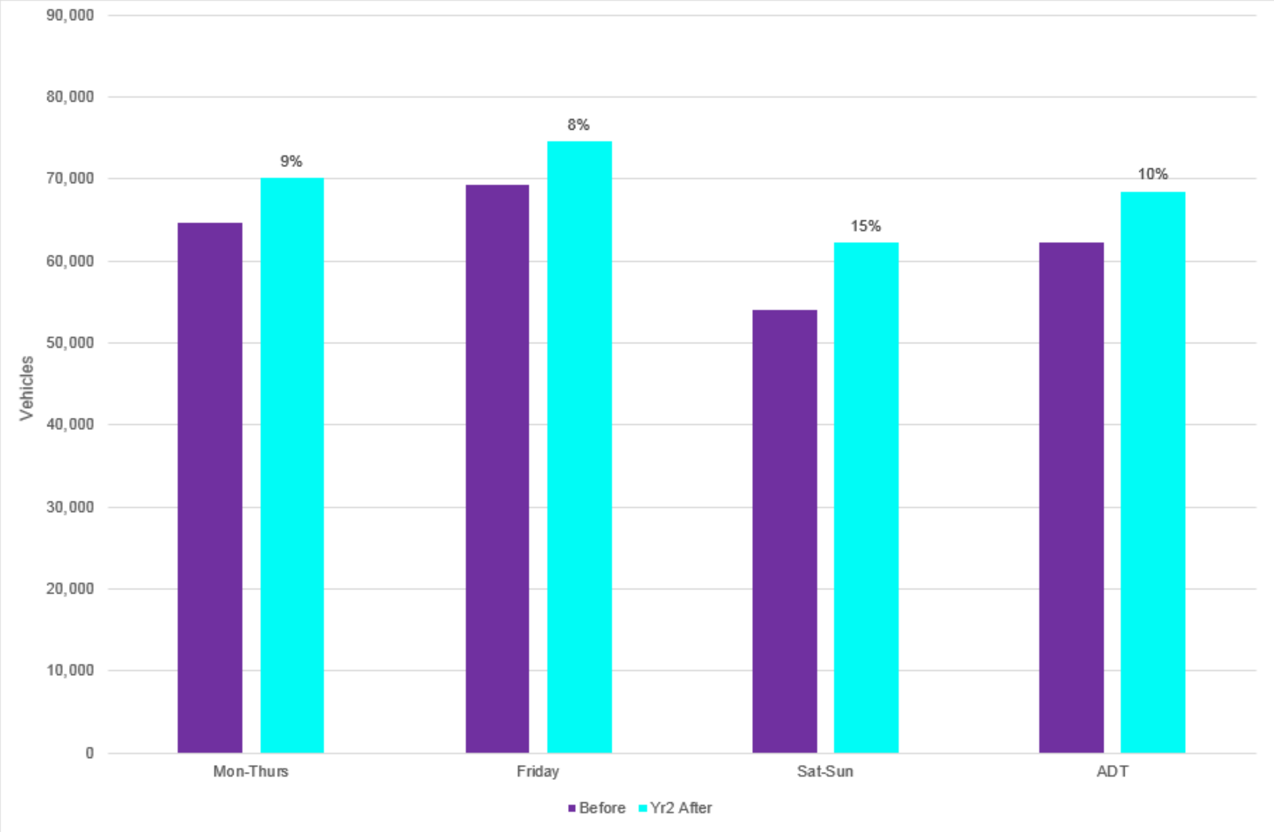


Figure 2-4 Average daily traffic by day type J23-J24 anticlockwise

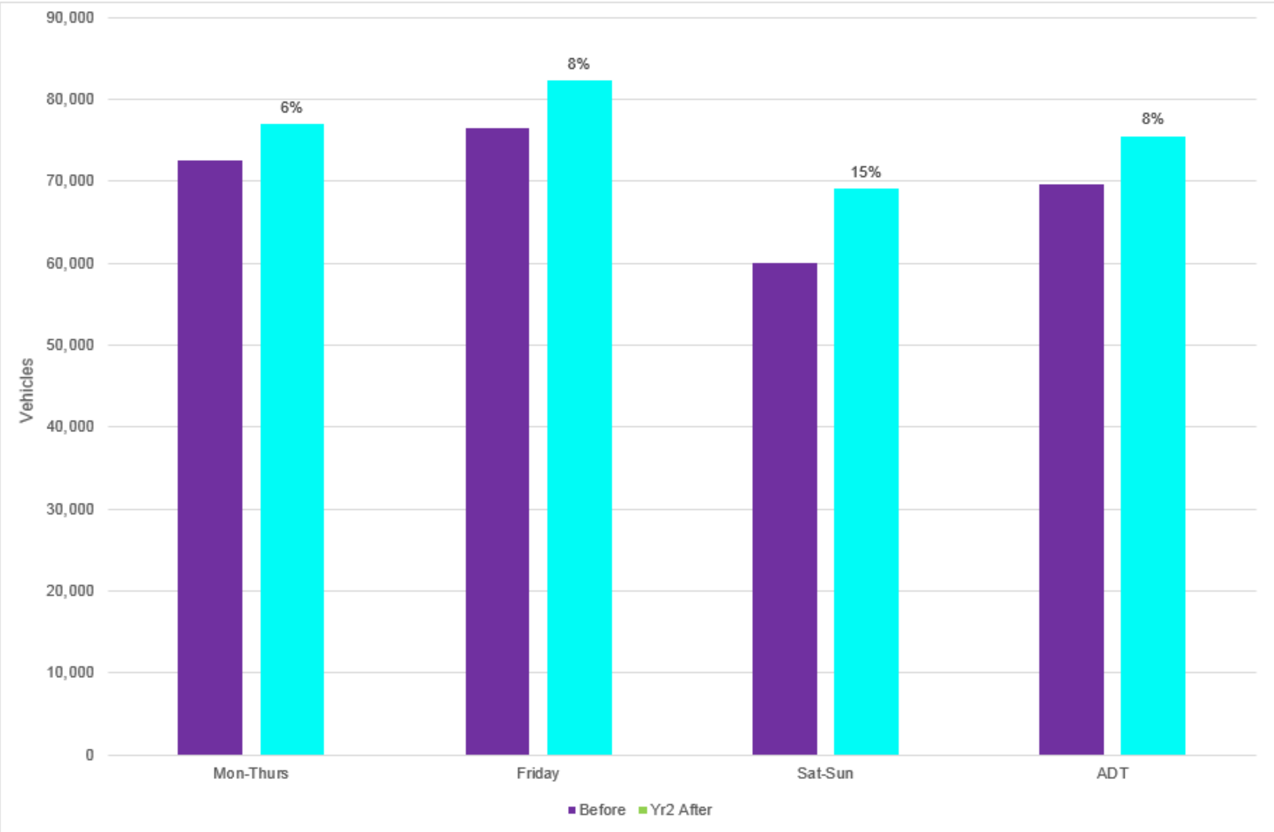


Figure 2-5 Average daily traffic by day type J24-J25 anticlockwise

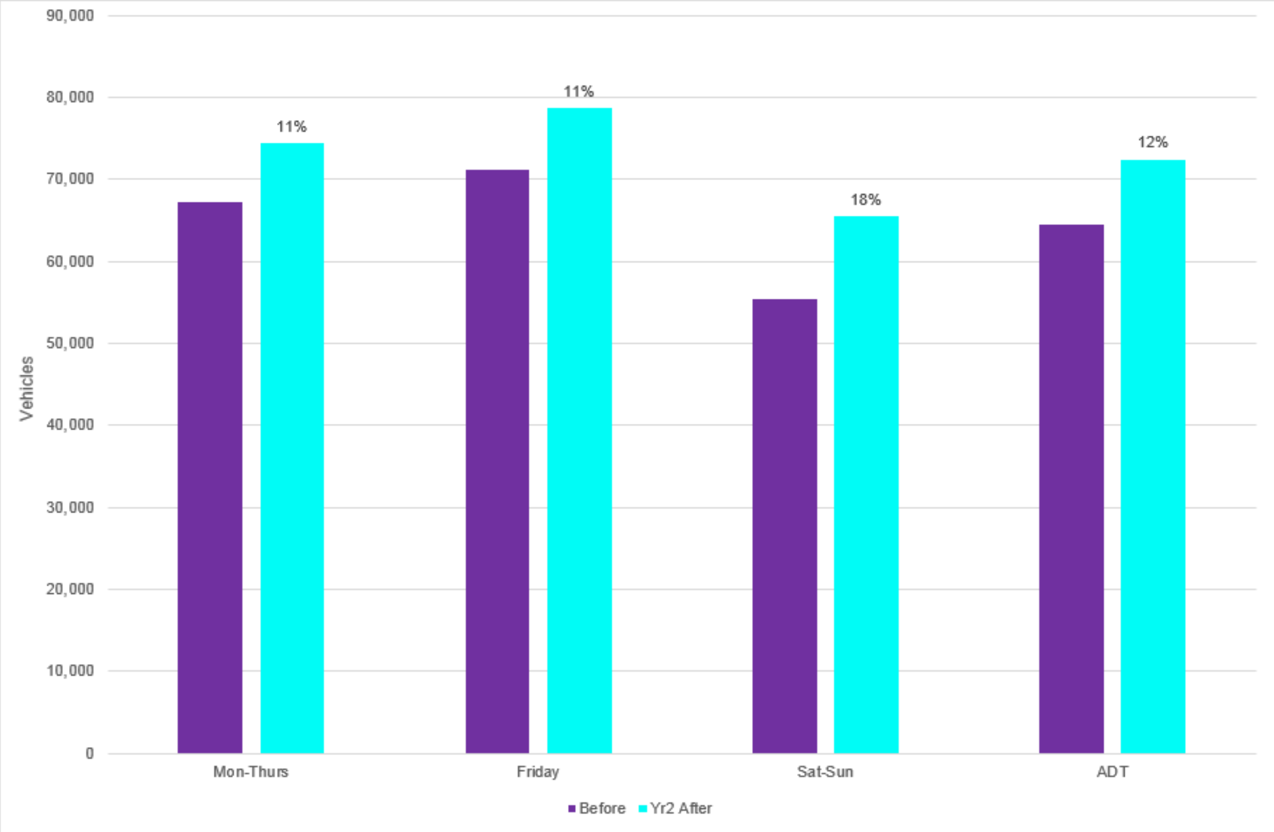
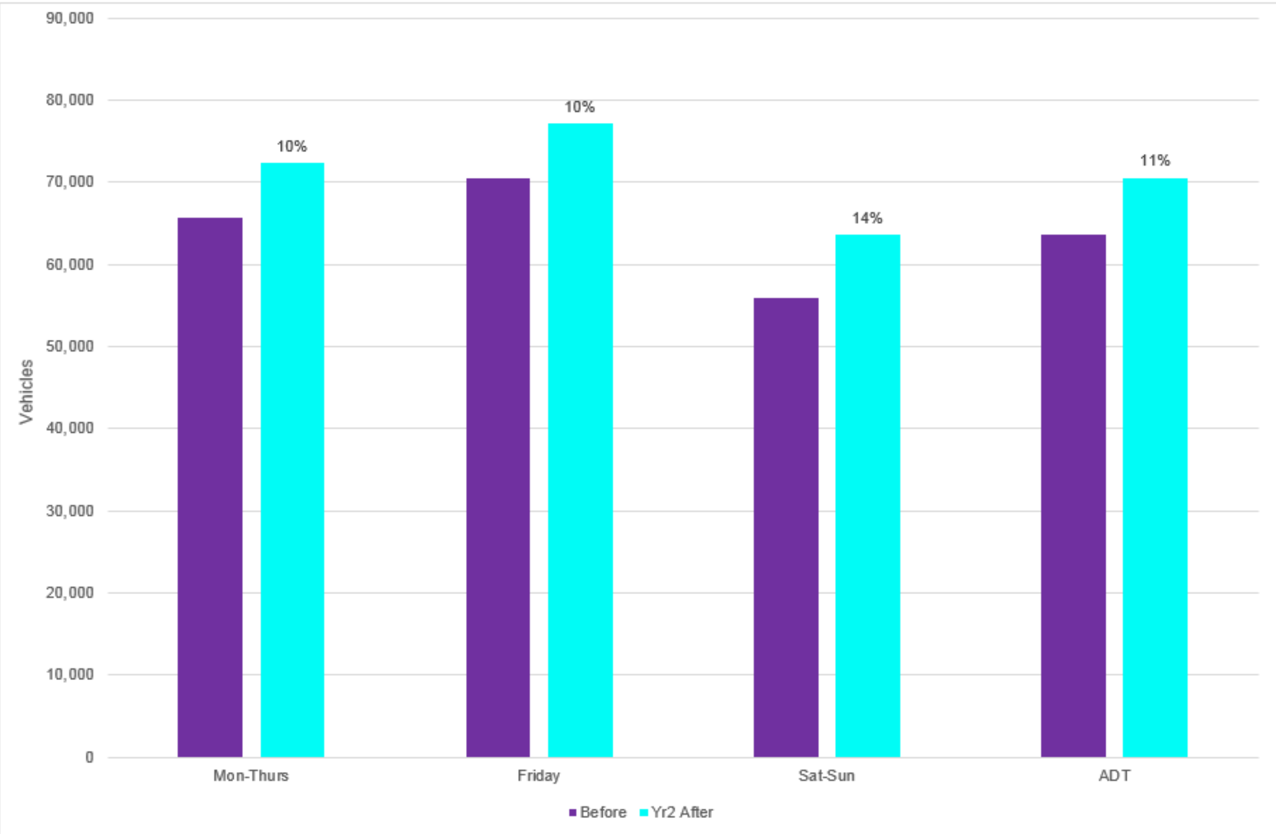


Figure 2-6 Average daily traffic by day type J25-J26 anticlockwise



The overall AADT over the 12 months of Before and Yr2 After traffic data has increased by between 8% (J23 to J24 anticlockwise) and 17% (J24 to J25 clockwise), with most other sections/directions experiencing an increase in traffic flow of between 10% and 12%.

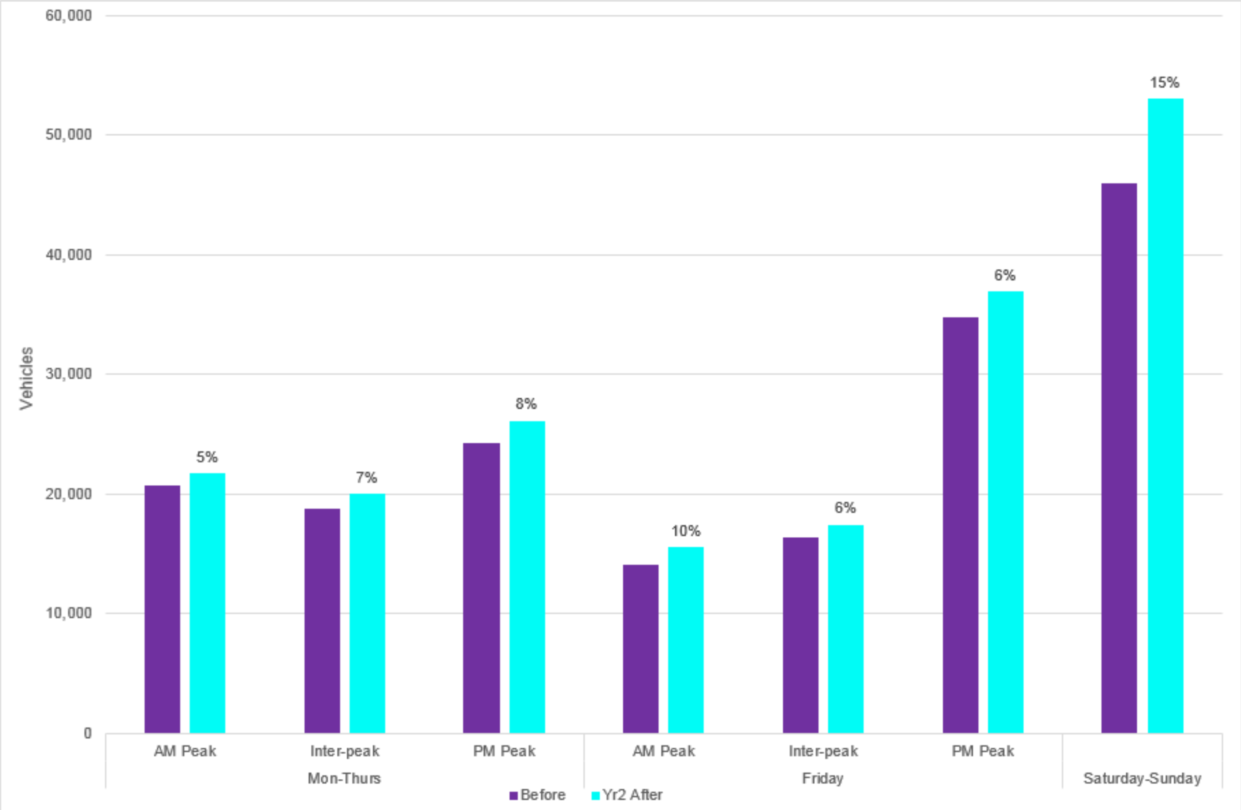
This can be considered against South East regional motorway traffic increasing between 2012 and 2015 by around 5%[2]. The growth along the scheme is far above that observed in the regional trends. Although the increase in traffic flows on the M25, facilitated by the scheme, will in itself contribute to the regional traffic trends, this is still a useful point to note when looking at link by link flow increases.

2.3. Flow over each time slice per link

Figure 2-7 to Figure 2-11 compare the average Before and Yr2 After flows by time slice for each link. The percentage change is shown above the Yr2 After bar in each case. The corresponding values are shown in Appendix A.2, with significant changes shown in bold text.

Clockwise, there are large flow increases on all links in all time slices. The largest increase can be seen at the weekend at 26%. The lowest increase is during the Friday inter-peak between J25 and J26 at 1%. The Mon-Thu AM peak for the same section is also lower than other time slices with an increase of 3%. In general, the largest increases in traffic flow can be seen between junctions J24 and J25.

Figure 2-7 Average flow by time slice J23-J24 clockwise



2 https://www.gov.uk/government/collections/road-traffic-statistics

Figure 2-8 Average flow by time slice J24-J25 clockwise

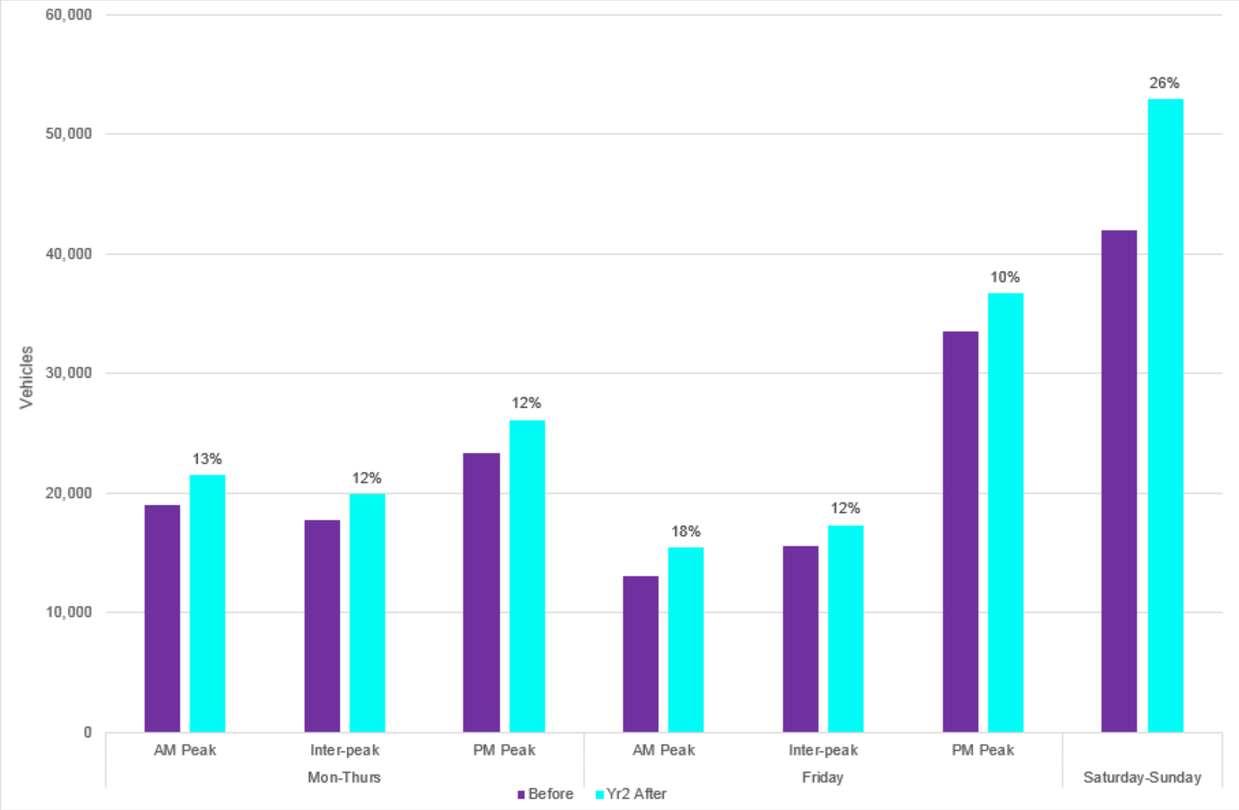
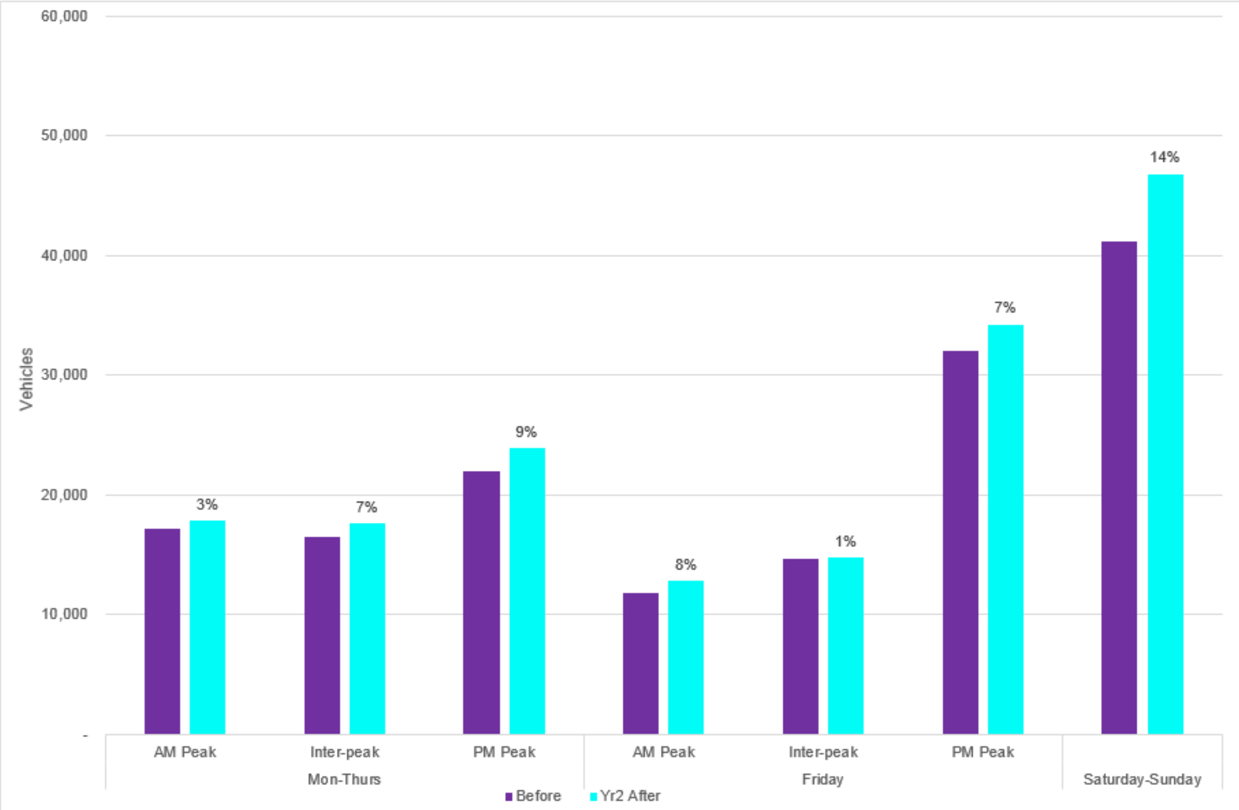


Figure 2-9 Average flow by time slice J25-J26 clockwise



Similarly to the daily traffic flows, most links and time slices see a large increase in traffic in the anticlockwise direction. The traffic flow increase is generally lower between J23 and J24. The largest increase is again seen between J24 and J25, with similar increases seen between J25 and J26. The largest increase is over the weekend between J24 and J25 and the smallest increases are during the Mon-Thu AM peak and the Friday PM peak between junctions J23 and J24.

Figure 2-10 Average flow by time slice J23-J24 anticlockwise

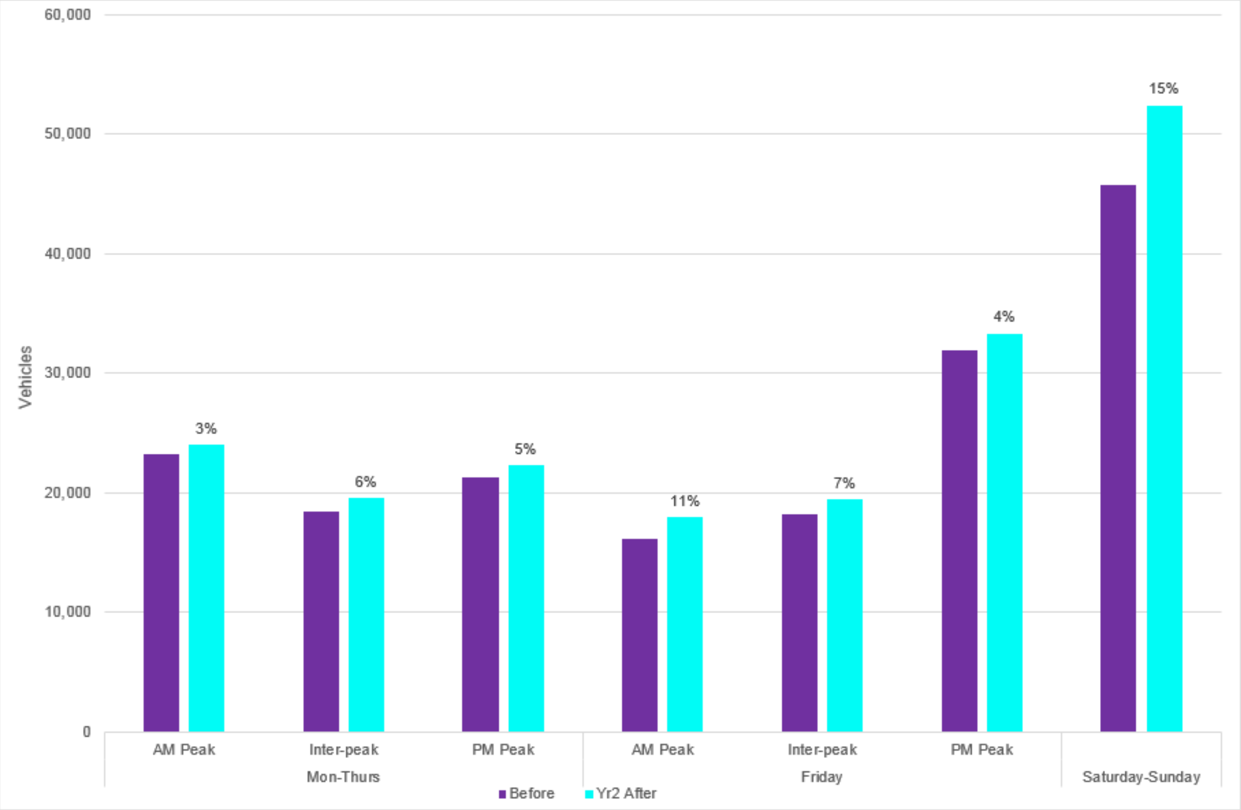


Figure 2-11 Average flow by time slice J24-J25 anticlockwise

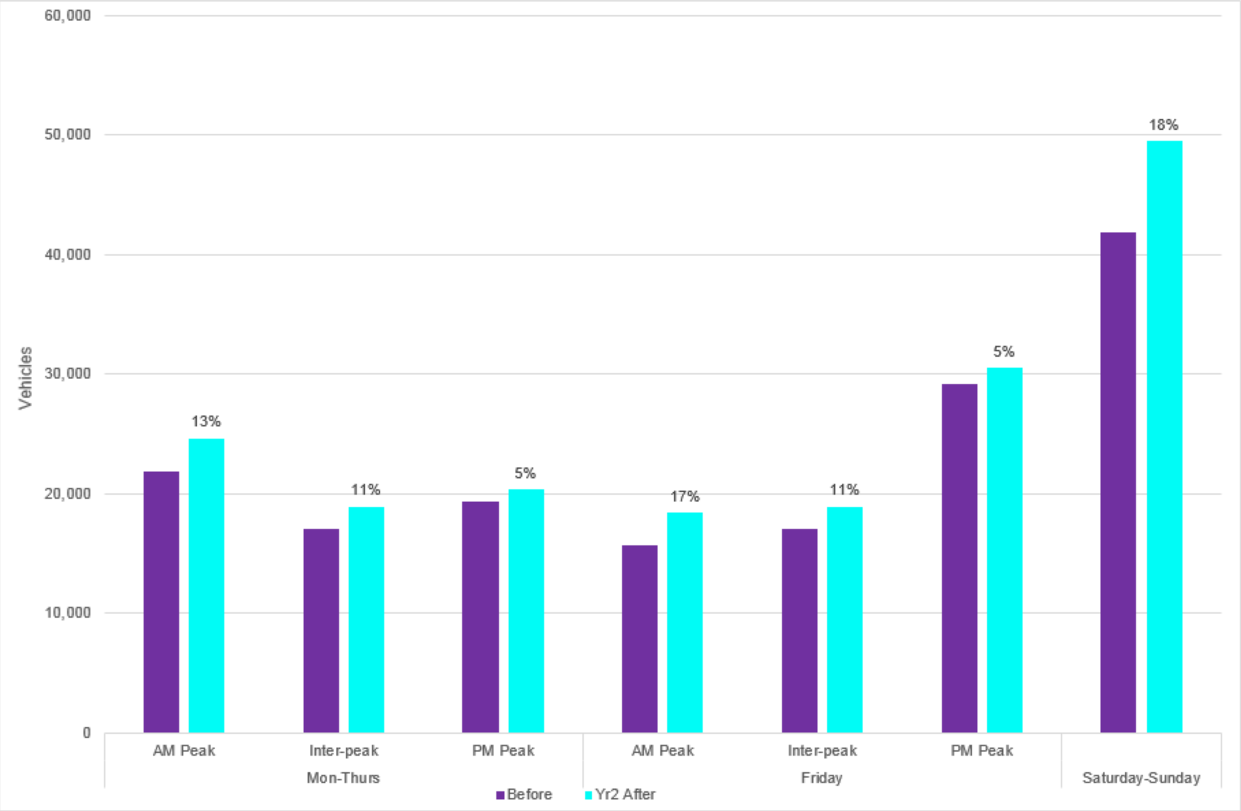
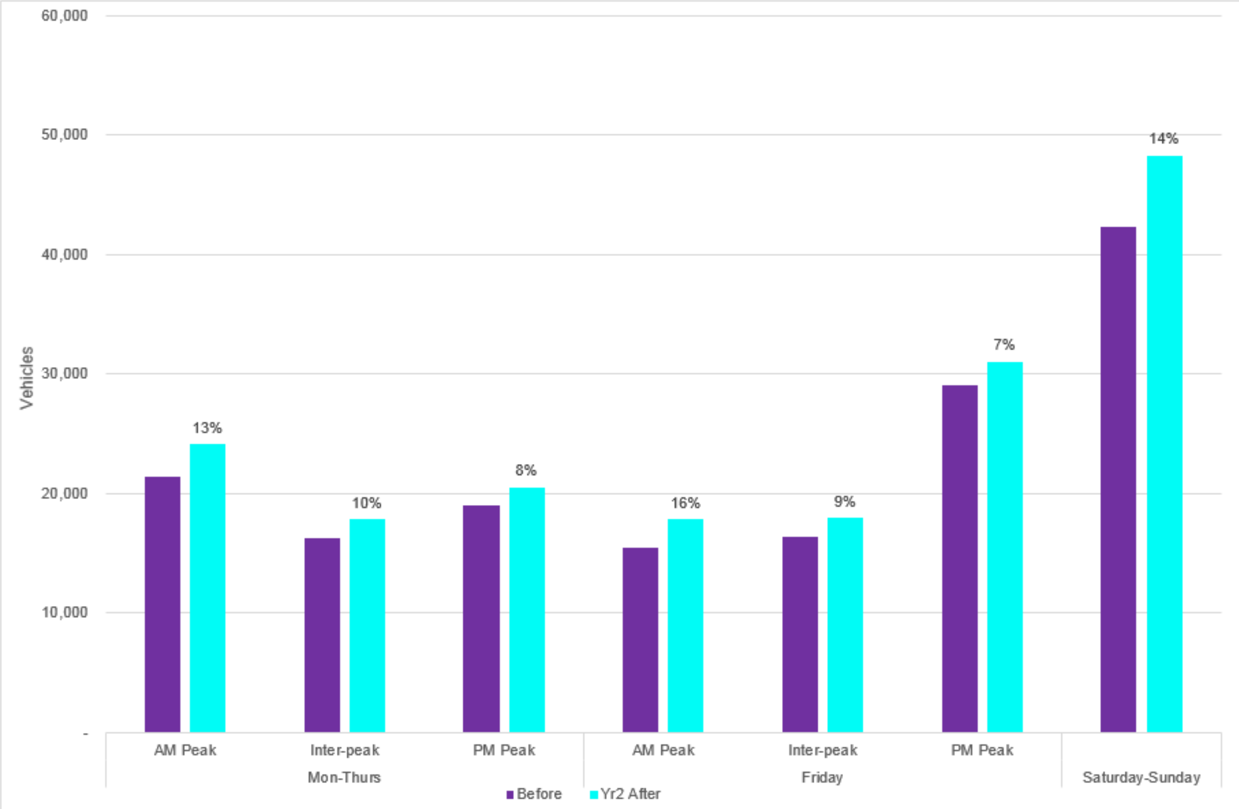


Figure 2-12 Average flow by time slice J25-J26 anticlockwise



2.4. Tests for statistical significance of the results

A sequence of t-tests was performed in order to assess whether the changes in the flows measured have been significant. In order to carry out these t-tests, the standard deviation, average flow and number of observations were calculated for each link in the section. An observation was considered to be a full day of data for each site on the link which was considered. This was required as the data has had to be collected and averaged for a number of sites in order to address the variability in the observations. The t-tests assumed that there was no change in the flow and tested for a statistically significant change using a two-tailed test at a 95% confidence level.

The results are presented in Table 2-1 for the flows by time slice and in Table 2-2 for the ADTs; the results are presented by a series of arrows denoting the type of change experienced in that time period. An up arrow denotes a statistically significant increase in flow, a down arrow denotes a statistically significant decrease, and a dash denotes no significant change in the time period.

Table 2-1 Flow by time slice t-tests

Direction	Location	Mon-Thurs			Friday			Saturday-Sunday
		AM Peak	Inter-peak	PM Peak	AM Peak	Inter-peak	PM Peak	
Clockwise	J23 - J24	↑	↑	↑	↑	↑	↑	↑
Clockwise	J24 - J25	↑	↑	↑	↑	↑	↑	↑
Clockwise	J25 - J26	-	-	-	-	-	-	-
Anticlockwise	J23 - J24	-	↑	↑	↑	↑	↑	↑
Anticlockwise	J24 - J25	↑	↑	↑	↑	↑	↑	↑
Anticlockwise	J25 - J26	↑	↑	↑	↑	↑	↑	↑

Table 2-2 ADT t-tests

Direction	Location	Mon-Thurs	Friday	Sat-Sun	ADT
Clockwise	J23 - J24	↑	↑	↑	↑
Clockwise	J24 - J25	↑	↑	↑	↑
Clockwise	J25 - J26	-	-	-	-
Anticlockwise	J23 - J24	↑	↑	↑	↑
Anticlockwise	J24 - J25	↑	↑	↑	↑
Anticlockwise	J25 - J26	↑	↑	↑	↑

From these results, it can be seen that the majority of the traffic flow changes have been shown to be significant. It should, however, be noted that no accommodation has been made for the background change in traffic levels which will in part have contributed to the growth along the scheme. No analysis has been completed between J25 and J26 clockwise as a result of the traffic data availability issues on this section.

2.5. Summary

The SM-ALR section has experienced traffic growth of over 10% between the Before and Yr2 After periods, which is far higher than regional motorway growth over the same period. The largest growth has generally been in the peak periods and at weekends, although anticlockwise J24 to J25 and J25 to J26 inter-peaks have also seen a high level of traffic growth.

3. Journey times

3.1. Introduction

This section outlines the changes in journey times and reliability on the M25 J23-27 SM-ALR between the Before and Yr2 After periods.

The data used was supplied by TomTom who provide anonymised data of journeys through the scheme during the Before and After periods. The journey time data is at a very spatially disaggregate level, allowing speed analysis to be undertaken at regular intervals along the scheme.

Before interrogating the TomTom database, a review of severe incidents and road works was undertaken to identify any days that should be removed from the analysis because they would not represent normal operating conditions. No such days were identified in the samples, therefore all days within the year are included in the dataset.

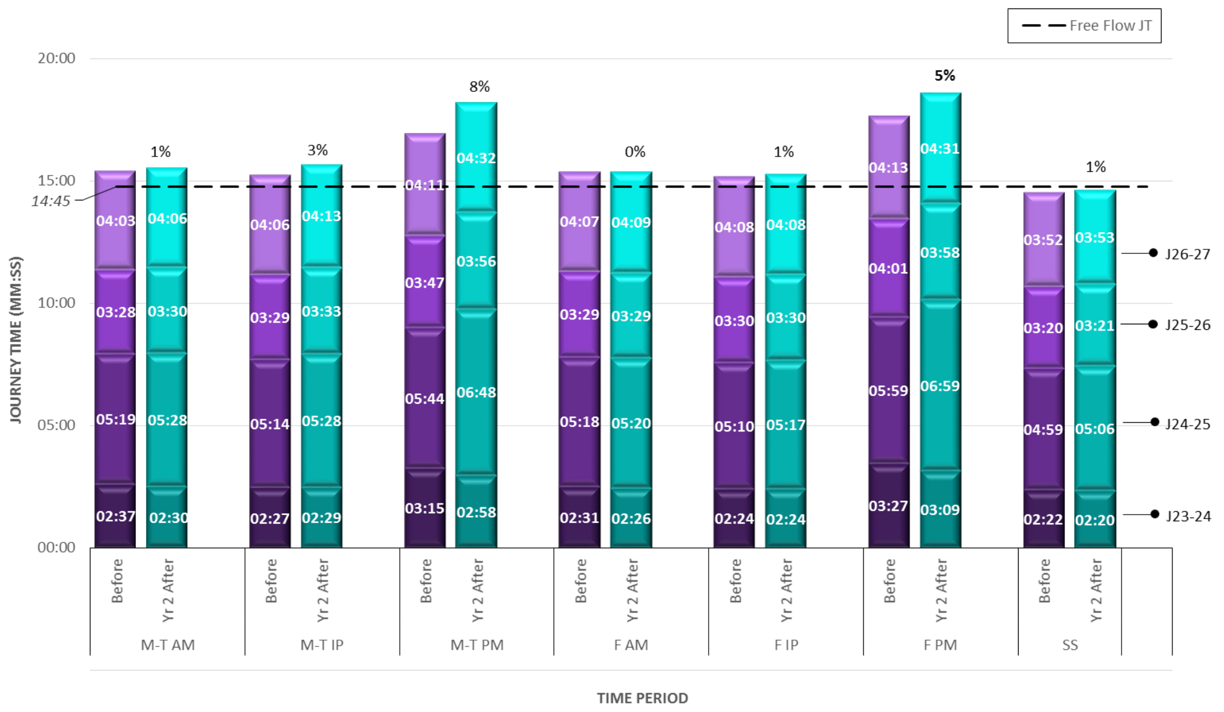
The journey time results presented in this section form the latest conclusions on journey time performance for the scheme following two years of operation.

3.2. Average journey time

The analysis of average journey times from junction to junction demonstrates the change in journey times at link level. The headline results are summarised in Figure 3-1 for clockwise and Figure 3-2 for anticlockwise with more detail provided in Appendix B.

Clockwise, between the Before and Yr2 After periods, there has been an average percentage increase of 3% (i.e. 26 seconds) across all day types and time slices from the average Before journey time of 15 minutes 47 seconds. The most congested periods were the weekday PM peaks and they have experienced worsened journey times (of 8% Mon-Thu and 5% Fri).

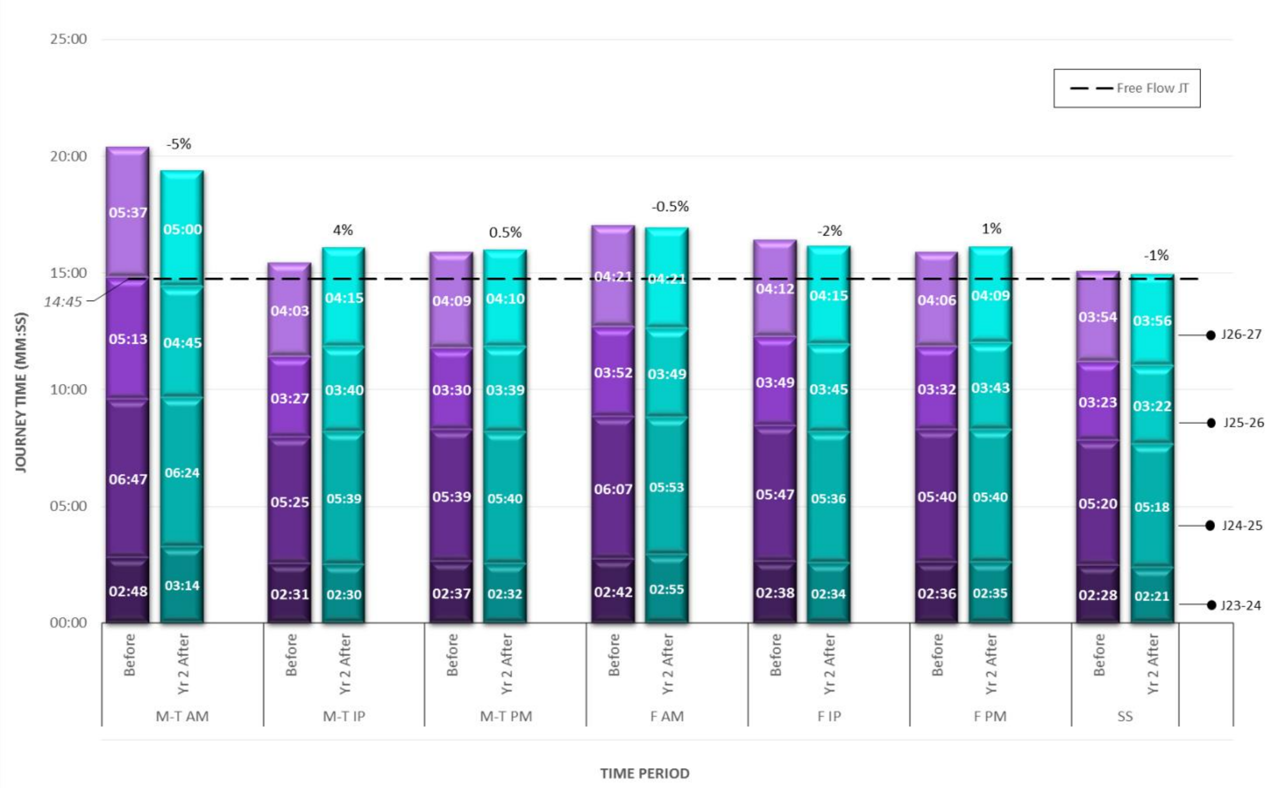
Figure 3-1 Clockwise journey time comparison



On individual links, the scheme has provided a slight journey time benefit on the J23-24 link with an overall decrease in average journey time of 7 seconds across all day types and time slices. The J24-25, J25-26 and J26-27 links have seen average journey time increases of 23 seconds, 2 seconds and 7 seconds respectively. So it appears that the J24-25 link has caused most of the additional delay in the After period. A review of congestion using MTV plots have revealed that there is often significant congestion approaching J25; sometimes the cause appears to be in the vicinity of the off-slip and sometimes in the region of the on-slip and Holmesdale Tunnel.

The roundabout at J25 has been the subject of review by Highways England in conjunction with TfL and other local authorities. It is currently being upgraded with new traffic signals equipment which could reduce the congestion in this area in the near future.

Figure 3-2 Anticlockwise journey time comparison



Anticlockwise, between the Before and Yr2 After periods, there has been an average percentage reduction of 0.5% (i.e. 5 seconds) across all day types and time slices. This means effectively no change in journey times from the average Before journey time of 16 minutes 37 seconds. The Mon-Thu AM peak periods experience the worst congestion; there has been a 5% journey time improvement but this is balanced by a worsening in the IP period.

The scheme has provided journey time benefits on the J24-25 link of 5 seconds across all day types and time slices. On the other links the journey times were virtually unchanged across all day types and time slices, although there were differences between the periods.

In summary, average journey times are nearly half a minute longer in the clockwise direction and almost unchanged anticlockwise.

3.3. Journey time reliability

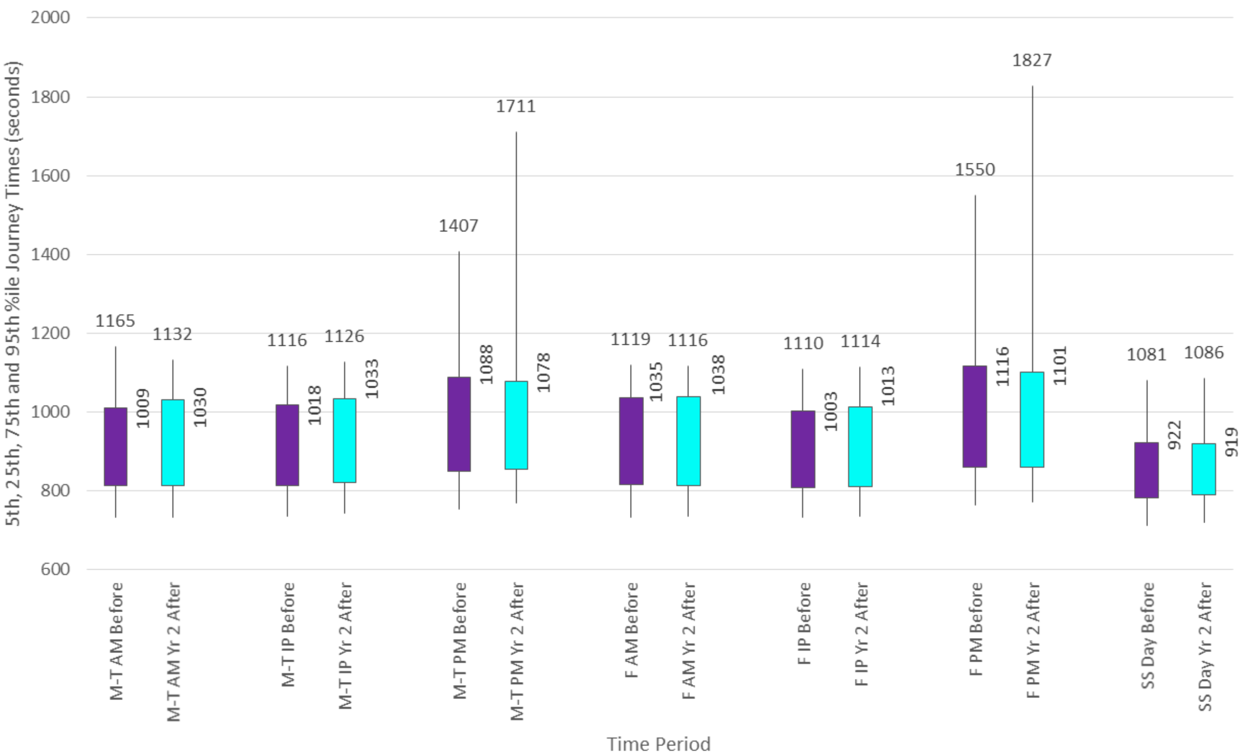
Reliability of journey times is a critical measure of a road's utility and function for road users. Percentile data has been used to understand the distribution of journey times through the scheme. Four metrics have been used, as shown in Table 3-1.

Table 3-1 Journey time metrics

Metric	Description
5th percentile	One in 20 vehicles are completing the journey faster than this, so it is a good measure of the best time achievable.
25th percentile	One in four vehicles are completing the journey faster than this and it is known as the lower quartile. The further this value is from the 5th percentile the more variability there is in the fastest journeys. It is an indicator that delays are experienced by a high proportion of all users.
75th percentile	Three quarters of vehicles complete the journey faster than this and it is a good measure of general variability from day to day of journey times.
95th percentile	95% of vehicles complete the journey faster than this, the remaining journeys are likely to be affected by incidents or heavy congestion. The further the 95th percentile journey time is from the 75th percentile the more heavily congested a journey is. This is an indication of incident related variability.

These four metrics are shown below in Figure 3-3 and Figure 3-4 as 'box and whisker' diagrams for each time slice, Before and Yr2 After. The box contains the 25th to 75th percentile range and the whiskers show the 5th and 95th percentile values. The 75th percentile and 95th percentile journey times are annotated on the plots.

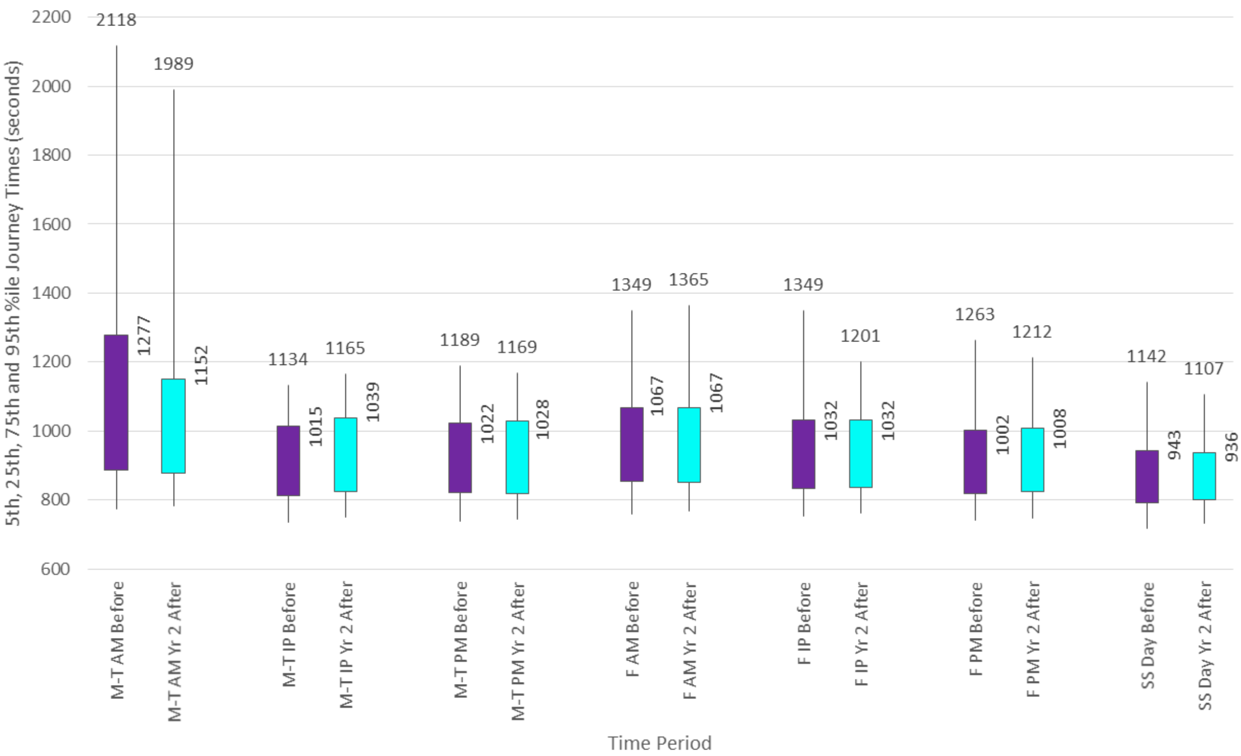
Figure 3-3 Clockwise journey time reliability analysis



Clockwise, the most unreliable journey times, Before and Yr2 After, are during the weekday PM peaks. Although the 95th percentile values of the weekday PM peaks increased, the variability in journey time experienced by the majority of road users during these periods has decreased (i.e. a reduced difference between the 25th and 75th percentile, the interquartile range). So journeys in the PM peaks are longer but more reliable; possibly due to the action of the variable mandatory speed limits.

In all other weekday periods, the interquartile range has increased very slightly, in the range of four to 21 seconds. This might be because when a vehicle stops in a live lane it is likely to cause more disruption than previously when the hard shoulder was available.

Figure 3-4 Anticlockwise journey time reliability analysis



Anticlockwise, the most unreliable journey time, Before and Yr2 After, is in the Monday-Thursday AM peak. This has experienced reductions in both the 95th percentile and the 75th percentile as well as the interquartile range. This shows better journey time reliability with the all lane running scheme.

In other (previously uncongested) periods, the interquartile range is similar between the Before and Yr1 After period, showing no change in day-to-day reliability.

3.4. Summary

Overall clockwise journey times have increased by 26 seconds (3%) in Yr2 After compared to Before. In the anticlockwise direction journey times have remained similar.

In both directions, delays have been identified with the cause in the region of J25. The roundabout at J25 has been the subject of review by Highways England in conjunction with TfL and other local authorities. It is currently being upgraded with new traffic signals equipment which could reduce the congestion in this area in the near future.

Journey time reliability clockwise remains similar between the Before and Yr2 After period using the interquartile measure, however the most delayed journeys as measured by the 95th percentile have noticeably increased in weekday PM peaks. Anticlockwise there is a good improvement on the Monday to Thursday AM time slice, while other time slices remain similar.

These results show that increases in capacity have been achieved, moving more goods, people and services, while maintaining journey times at pre-scheme levels and slightly improving reliability.

4. Safety

4.1. Introduction

This section compares the Before and After safety performance of the M25 J23 to J27 SM-ALR scheme. STATS19 data has been used to identify the number and rate of personal injury collisions, however it should be noted that the After period (two years for J23 to J25 and 18 months for J25 to J27) is a relatively short sample period; a larger data set is required before the findings will become statistically significant and conclusions can be drawn. (The minimum desirable period for collision data analysis results to become statistically significant is three years.) However emerging safety data provides an extremely beneficial insight into the performance of ALR.

STATS19 collates all injury collision data in a consistent manner each year and is a generally reliable source for numbers of injury collisions. Damage-only collisions are not recorded in STATS19 so it is not a record of all collisions. Recording collision details relies on police input at the collision scene, therefore there is some scope for inconsistencies when the information is recorded. This data is robust to the extent that it is unlikely to change significantly when the validated results are produced.

This section also contains analysis of Red X and speed limit compliance and ERA usage in the After period.

Note that it was not possible to measure flows accurately between J25 and J27, so the flows used for the rate calculations have been estimated by comparing with adjacent links and alternative data sources (DfT manual count data). This means the rate calculations must be treated with caution.

4.2. Number and rate of collisions

Table 4-1 shows the number of collisions during the Before and After periods, the rate of collisions and the percentage change. The number of collisions is exactly half in the After period which is half as long as the Before, however the traffic flows have increased leading to a slight reduction in collision rate. To fully understand the results we also need to take into account the background trend in collisions, see Section 4.2.1.

Table 4-1 Number of collisions by severity and collision rates

Period		Fatal	Serious	*Fatal & serious*	Slight	Total
Before	Year 1	1	11	12	85	97
	Year 2	2	11	13	88	101
	Year 3	1	5	6	87	93
	Total	4	27	31	260	291
	Collision rate (collisions per hmvm) (22.6 hmvm)	0.177	1.194	1.371	11.500	12.871
	Collision rate (collisions per mvkm) (3,641 mvkm)	0.001	0.007	0.009	0.071	0.080
After*	Year 1	2	3	5	55	60
	Year 2	1	9	10	93	103
	Total	3	12	15	148	163
	Collision rate (collisions per hmvm) (14.2 hmvm)	0.212	0.847	1.059	10.444	11.502
	Collision rate (collisions per mvkm) (2,281 mvkm)	0.001	0.005	0.007	0.065	0.071

*Due to staged opening this is based on 24 months of data for J23 to J25 and 18 months of data for J25 to J27. Total values cannot be compared between Before and After periods, but rates can be compared.

The four fatal collisions in the Before period include:

- A car transporter losing control for unknown reasons and striking street lighting;
- A motorcyclist weaving through traffic and colliding with a vehicle;
- A vehicle drifting across lanes and losing control; and
- A suspected suicide where a pedestrian ran out into the carriageway.

There were three fatal collisions in the After period, as follows:

- A stowaway incident where a pedestrian climbed out from underneath a vehicle and was run over;
- A suspected suicide attempt where a car pulled out from the nearside verge (actually a very short length of hard shoulder) into the path of an HGV in lane 1 causing the HGV to swerve and collide with another HGV causing a crossover and ultimately the fatality of an HGV occupant on the opposite carriageway; and
- A slow moving / stationary vehicle in lane 1 was struck by another vehicle.

There were a total of 12 serious collisions in the After period, as follows:

- Four nose to tail collisions:
  - A bus or coach braked and was hit from behind by an HGV;
  - An HGV collided with a van in front for unknown reasons;
  - Two cars were braking and the second vehicle was hit from behind by a third car which pushed the second vehicle into the first vehicle; and
  - A car was hit from behind by an HGV which pushed it into a car in front. The front vehicle lost control, striking the central reserve barrier and rebounded across the carriageway into the nearside barrier and off the motorway. A toddler in the middle vehicle was being carried on the lap of a pregnant passenger and suffered serious injuries.
- Three collisions associated with lane changing and/or failing to look:
  - An HGV moved from lane 1 into lane 2, colliding with a van in lane 2;
  - A car moved from lane 3 into lane 2, colliding with a car in lane 2. The first car left the scene; and
  - A car moved from lane 1 of the slip road for the M11 Northbound into lane 2 for the M11 Southbound. A motorbike already in lane 2 could not stop and hit the rear of the car, unseating the rider.
- Four single vehicle collisions:
  - A driver who had fallen asleep woke as their car was about to collide with an HGV, panicked and lost control, striking the nearside and then offside tunnel walls;
  - A vehicle left the motorway to the offside for unknown reasons, struck the central reserve barrier and caught fire;
  - A vehicle left the motorway to the nearside, struck the tunnel wall and came to rest in the hard shoulder; and
  - An HGV lost control and turned onto its side.
- One other collision where a car entered a slip road which was closed for recovery work and collided with a road worker. The car failed to stop at the scene.

It can be seen the serious collisions could have occurred on any stretch of motorway so are not attributable to ALR. The contributory factors by severity for the collisions are shown Appendix C.1.

4.2.1. Background trend in collisions

There is a trend over time leading to a reduction in the number of personal injury collisions against a trend of increasing traffic volumes. The reasons for the reduction are wide ranging and include improved safety measures in vehicles. This trend needs to be accounted for when comparing the Before and After periods.

The best way to take into account the national trend is to assume that, if the scheme had not been built, the number of collisions on the roads in the study area would have dropped at the same rate as they did nationally during the same time period. This provides what is known as a counterfactual ‘without scheme’ scenario and can be compared on a like-for-like basis with the observed After data which is the ‘with scheme' scenario[3]. The difference between the numbers of collisions in these two scenarios can then be attributed to the scheme rather than the wider national trends.

Table 4-2 shows that there has been a very small increase in the collision rate of 1% over and above the background reduction in collisions (compared to the 11% absolute reduction in Table 4-1).

Table 4-2 Number of collisions and collision rates following national trends

Period	Number of collisions	Collision rate (collisions per hmvm)	Collision rate (collisions per mvkm)
Annual average Before period	97.00	12.87	0.080
Counter factual Before period	92.52	11.41	0.071
After*	163	11.50	0.071
Annual average After period	93.14		

*Due to staged opening this is based on 24 months of data for J23 to J25 and 18 months of data for J25 to J27. Total values cannot be compared between Before and After periods, but rates can be compared.

4.2.2. Statistical significance

A Chi squared test compared the number of Before and After collisions and Annual Average Daily Traffic flows (AADTs) against expected values if there was no change. The test result indicates that the change in the collision rate is not statistically significant and therefore not necessarily a direct impact of the scheme. This means that neither the 11% reduction, nor the 1% increase compared to background trends, can be attributed to the scheme.

4.3. Casualties, FWI and KSI rate

Fatal Weighted Injury (FWI)[4] is calculated based on the number of fatal, serious and slight casualties as weighted proportions, to adjust for the severity. The FWI rate allows a comparison between road sections of different flows and lengths.

The slight reduction in the FWI rate shown in Table 4-3 is attributable to the lower number of serious and slight casualties in the After period, however this is based on a small After sample size so is not statistically significant.

Table 4-3 Number of casualties and FWI rate

Period	Severity			Total	FWI	FWI rate per hmvm	FWI rate per bvkm
	Fatal	Serious	Slight				
Before (36 months) (22.6 hmvm, 3.64 bvkm)	4	36	401	441	11.61	0.51	3.19
After* (14.2 hmvm, 2.28 bvkm)	3	16	233	252	6.93	0.49	3.04

*Due to staged opening this is based on 24 months of data for J23 to J25 and 18 months of data for J25 to J27. Total values cannot be compared between Before and After periods, but rates can be compared.

There has been a reduction in the Killed or Seriously Injured (KSI) rate, shown in Table 4-4, which is attributable to the lower number of serious casualties in the After period. However this is based on a small After sample size so, again, is not statistically significant.

[3] The counterfactual factor is calculated using the national collision data for motorway class roads in the After period (2015) and for the middle year in the Before period (2011). The calculated factor between these years is 0.95 for the number of collisions and 0.89 for the collision rate.
[4] FWI is defined as: (number of fatalities) + 0.1 x (number of serious casualties) + 0.01 x (number of slight casualties).

Table 4-4 Total KSI and KSI rate

Period	Total KSI	KSI rate per hmvm	KSI rate per bvkm
Before (36 months) (22.6 hmvm, 3.64 bvkm)	40	1.77	10.99
After* (14.2 hmvm, 2.28 bvkm)	19	1.34	8.33

*Due to staged opening this is based on 24 months of data for J23 to J25 and 18 months of data for J25 to J27. Total values cannot be compared between Before and After periods, but rates can be compared.

4.4. Additional analysis

4.4.1. Red X (lane closed) analysis

An analysis of Red X compliance was undertaken using HALOGEN data for Sign and Signal settings and MIDAS TCD files for minutely flows per lane. The two data sets were combined to identify lane closures and flows along the lane during the restriction. An example of a Red X event is presented in Figure 4-1.

Figure 4-1 Example lane closure event

Direction of travel

	Detector/Signal Location	MS4 Message	Minutely Flow During Lane Closure L1	L2	L3	L4
	M25/5413B		7	21	30	32
MS4	5413B	NR				
	M25/5419B		0	12	11	10
MS4 & AMIs	5419B	LANE CLOSED FOR INCIDENT ACCESS	*X*	(40)	(40)	(40)
	M25/5424B		1	24	29	32
	M25/5429B		2	21	30	28
	M25/5432B		1	22	28	29
MS4	5432B	DO NOT USE CLOSED LANES xIII (40)				
	M25/5437B		2	21	25	28
	M25/5441B		1	20	27	27
	M25/5445B		2	23	24	28
MS4	5445B	DO NOT USE CLOSED LANES xIII (40)				
	M25/5449B		2	21	25	26
	M25/5453B		1	21	28	28
MS4	5453B	Congestion stay in lane /III (50)				
	M25/5458B		3	21	24	28
J25 Merge	M25/5464B		2	14	15	15

Key:

5381B	Signal
M25/5381B	Detector site
L1	Lane 1
L2	Lane 2
L3	Lane 3
L4	Lane 4
(60)	60mph VMSL
(50)	50mph VMSL
(40)	40mph VMSL
LDR	Lane Divert Right Arrow
X	Red X on gantry indicating closed lane
xIII	Wickets on MS4 Sign showing lane 1 closure
xxII	Wickets on MS4 Sign showing lane 1 and lane 2 closure
/III	Wickets on MS4 Sign showing lane divert right
NR	National Speed Limit

A total of 20 lane closures have been assessed in the Yr2 After period and the results are summarised in Appendix C.2. The per-lane minutely flow is provided to give an indication of how busy the motorway was; a flow of 30 vehicles per minute per lane is a high flow (one vehicle every 2 seconds).

Non-compliance in this sample ranges from 1 to 5 vehicles per minute, 1% to 10% of total flow; across all Red X events analysed the minutely average flow of non-compliant vehicles was 2 per minute. Compliance with Red X as a percentage of total flow was 96%, which appears to show a slight improvement from the 93% in the Yr1 After period, although the sample size is relatively low.

The percentage non-compliance was compared to the incident duration and traffic flow; no correlation was found with either. This suggests that the subset of drivers who choose not to comply with Red Xs do so regardless of how busy the motorway is or how long the incident duration is.

4.4.2. ERA monitoring

The ERA monitoring was undertaken to identify the causes of ERA stops, vehicle types and risks of entering, stopping or exiting the ERA. Six ERAs were identified for continuous monitoring covering both peaks and inter-peak. A total of 240 hours ERA monitoring was divided between the following ERAs:

- ERA 1 – M25 anticlockwise between J23 and J24 at 5400B;
- ERA 2 – M25 clockwise between J25 and J26 at 5501A;
- ERA 3 – M25 anticlockwise between J25 and J26 at 5508B;
- ERA 4 – M25 clockwise between J25 and J26 at 5511A;
- ERA 5 – M25 clockwise between J25 and J26 at 5524A; and
- ERA 6 – M25 anticlockwise between J26 and J27 at 5545B.

In total 119 unique ERA stops were observed. This means stops by a lead vehicle; further related vehicle activity such as Highways England Traffic Officer services or recovery vehicles are not counted. A summary of ERA activity can be seen in Table 4-5.

Table 4-5 Summary of ERA activity

Activity	Number	Percentage of all stops
Emergency Refuge Telephone (ERT) used	4	3%
Highways England Traffic Officer attended	8	7%
Non-emergency (e.g. drove off without exiting vehicle, comfort break etc.)	97	82%
Genuine reason (e.g. problem with vehicle)	22	18%

The 119 unique ERA stops over 240 hours of ERAs monitored gives a rate of approximately 0.5 stops per hour per ERA. From the sample observed it was judged that 82% were non-emergency, a slight decrease from the 85% non-emergency stops in Yr1 After.

A breakdown of the types of lead vehicles which stopped in ERAs and whether they were genuine emergencies is shown in Table 4-6. As cars make up the majority of vehicles on the road it is not surprising that they account for the most stops. HGVs represented the highest non-emergency use of ERAs, at 91%. This compares with 96% of HGVs stopping for a non-emergency reason in Yr1 After, these numbers are fairly consistent. For the entire After period, the non-emergency stops for HGVs is 93%.

Other ERA observations were:

- no instances of problems with ERA operation were observed; and
- no collisions relating to vehicles exiting ERAs.

Table 4-6 Vehicle types using ERAs

Vehicle type	Number of ERA stops	Percentage of total	Non-emergency	Genuine emergency
Car	52	44%	75%	25%
Van	30	25%	83%	17%
HGV	32	27%	91%	9%
LGV	5	4%	80%	20%
Total	119		82%	18%

4.5. Summary

The After period STATS19 sample size is small so the results are not conclusive, although they provide a beneficial insight into the performance of ALR. There is a very small increase in the collision rate, over and above the national background trend of improved safety; this is not statistically significant and should be considered as ‘no significant change’. This suggests that the scheme is achieving its objective of maintaining safety performance, although further monitoring is required due to the small sample size.

Monitoring of Red X compliance revealed that across all events analysed, an average of 4% of vehicles did not comply with Red Xs in the Yr2 After period.

Approximately 0.5 ERA stops per hour per ERA were observed during monitoring of CCTV, the same as Yr1 After monitoring. It was judged that 82% were non-emergency. HGVs make a higher proportion of ERA stops compared to the general vehicle make up and also had a very high non-emergency use of ERAs at 91%.

5. Conclusions

5.1. Flow

The SM-ALR section has experienced traffic growth of over 10% between the Before and Yr2 After periods, which is far higher than regional motorway growth over the same period. The largest growth has generally been in the peak periods and at weekends, although anticlockwise J24 to J25 and J25 to J26 inter-peaks have also seen a high level of traffic growth. No data was available for J26 to J27.

5.2. Journey time

Overall clockwise journey times have increased by 26 seconds (3%) in Yr2 After compared to Before. In the anticlockwise direction journey times have remained similar.

In both directions, delays have been identified with the cause in the region of J25. The roundabout at J25 has been the subject of review by Highways England in conjunction with TfL and other local authorities. It is currently being upgraded with new traffic signals equipment which could reduce the congestion in this area in the near future.

Journey time reliability clockwise remains similar between the Before and Yr2 After period using the interquartile measure, however the most delayed journeys as measured by the 95th percentile have noticeably increased in weekday PM peaks. Anticlockwise there is a good improvement on the Monday to Thursday AM time slice, while other time slices remain similar.

5.3. Safety

The After period STATS19 sample size is small so the results are not conclusive. There is a very small (but not statistically significant) increase in the collision rate, over and above the national background trend of improved safety. However, reductions have been seen in the severity index and the FWI and KSI rates but no conclusions should be drawn from this due to the small sample size.

Monitoring of Red X compliance revealed that across all events analysed, an average of 4% of vehicles did not comply with Red Xs in the Yr2 After period.

Approximately 0.5 ERA stops per hour per ERA were observed during monitoring of CCTV, the same as Yr1 After monitoring. It was judged that 82% were non-emergency. HGVs make a higher proportion of ERA stops compared to the general vehicle make up and also had a very high non-emergency use of ERAs at 91%.

Appendices

Appendix A. Flows additional information

A.1. 24 hour average daily traffic (ADT)

The table below shows the values for ADTs Before and After.

Location	Value	Clockwise				Anticlockwise			
		Mon-Thurs	**Friday**	**Sat-Sun**	**ADT**	**Mon-Thurs**	**Friday**	**Sat-Sun**	**ADT**
J23 - J24	Before	73,700	77,300	60,500	70,500	72,600	76,500	60,000	69,600
	Yr2 After	79,800	83,600	70,300	77,600	77,000	82,300	69,100	75,500
	Change	6,100	6,300	9,800	7,100	4,400	5,800	9,100	5,900
	% Change (against Before)	**8%**	**8%**	**16%**	**10%**	**6%**	**8%**	**15%**	**8%**
J24 - J25	Before	69,800	73,500	55,700	66,300	67,300	71,100	55,400	64,400
	Yr2 After	79,500	83,400	70,200	77,400	74,400	78,700	65,500	72,400
	Change	9,700	9,900	14,500	11,100	7,100	7,600	10,100	8,000
	% Change (against Before)	**14%**	**13%**	**26%**	**17%**	**11%**	**11%**	**18%**	**12%**
J25 - J26	Before	64,600	69,200	54,100	62,300	65,700	70,400	55,900	63,600
	Yr2 After	70,100	74,600	62,200	68,500	72,300	77,100	63,600	70,500
	Change	5,500	5,400	8,100	6,200	6,600	6,700	7,700	6,900
	% Change (against Before)	**9%**	**8%**	**15%**	**10%**	**10%**	**10%**	**14%**	**11%**

A.2. Flows by time slice

The table below shows the flows for each time slice in the clockwise direction.

Clockwise flows by time slice								
Location	Value	Mon-Thurs			Friday			Saturday-Sunday
		AM Peak	Inter-peak	PM Peak	AM Peak	Inter-peak	PM Peak	
J23 - J24	Before	20,700	18,700	24,200	14,100	16,400	34,700	46,000
	Yr2 After	21,700	20,000	26,100	15,500	17,400	36,900	53,000
	Change	1,000	1,300	1,900	1,400	1,000	2,200	7,000
	% Change	**5%**	**7%**	**8%**	**10%**	**6%**	**6%**	**15%**
J24 - J25	Before	19,000	17,700	23,300	13,000	15,500	33,500	42,000
	Yr2 After	21,500	19,900	26,100	15,400	17,300	36,700	52,900
	Change	2,500	2,200	2,800	2,400	1,800	3,200	10,900
	% Change	**13%**	**12%**	**12%**	**18%**	**12%**	**10%**	**26%**
J25 - J26	Before	17,200	16,500	21,900	11,800	14,600	32,000	41,200
	Yr2 After	17,800	17,600	23,900	12,800	14,700	34,200	46,800
	Change	600	1,100	2,000	1,000	100	2,200	5,600
	% Change	**3%**	**7%**	**9%**	**8%**	**1%**	**7%**	**14%**

The table below shows the flows for each time slice in the anticlockwise direction.

Anticlockwise flows by time slice								
Location	Value	Mon-Thurs			Friday			Saturday-Sunday
		AM Peak	Inter-peak	PM Peak	AM Peak	Inter-peak	PM Peak	
J23 - J24	Before	23,200	18,400	21,300	16,100	18,200	31,900	45,700
	Yr2 After	24,000	19,500	22,300	17,900	19,400	33,300	52,400
	Change	800	1,100	1,000	1,800	1,200	1,400	6,700
	% Change	**3%**	**6%**	**5%**	**11%**	**7%**	**4%**	**15%**
J24 - J25	Before	21,800	17,000	19,300	15,700	17,000	29,100	41,900
	Yr2 After	24,600	18,900	20,300	18,400	18,900	30,500	49,500
	Change	2,800	1,900	1,000	2,700	1,900	1,400	7,600
	% Change	**13%**	**11%**	**5%**	**17%**	**11%**	**5%**	**18%**
J25 - J26	Before	21,400	16,200	19,000	15,400	16,400	29,000	42,300
	Yr2 After	24,100	17,800	20,500	17,800	17,900	31,000	48,300
	Change	2,700	1,600	1,500	2,400	1,500	2,000	6,000
	% Change	**13%**	**10%**	**8%**	**16%**	**9%**	**7%**	**14%**

Appendix B. Journey times additional information

B.1. Days in sample

The table below shows the date ranges and number of days used in the data set for the analysis:

Period		Clockwise	Anticlockwise
Before	From	1 Feb 12	1 Feb 12
	To	31 Jan 13	31 Jan 13
	Days removed	0	0
	Days in sample	365	365
Yr2 After	From	1 May 15	1 May 15
	To	30 Apr 16	30 Apr 16
	Days removed	0	0
	Days in sample	365	365

B.2. Journey time

B.2.1. Average journey time

The tables below show the results. Where Yr2 After period journey times have become longer they are highlighted in red.

Clockwise Journey Time Comparison

	Section	Distance (miles)	M-T AM	M-T IP	M-T PM	F AM	F IP	F PM	SS	Period average % change
Before	J23 to J24	2.5	02:37	02:27	03:15	02:31	02:24	03:27	02:22	
	J24 to J25	5.6	05:19	05:14	05:44	05:18	05:10	05:59	04:59	
	J25 to J26	3.6	03:28	03:29	03:47	03:29	03:30	04:01	03:20	
	J26 to J27	4.4	04:03	04:06	04:11	04:07	04:08	04:13	03:52	
	Total	16.1	15:26	15:17	16:57	15:24	15:13	17:40	14:32	
Yr2 After	J23 to J24	2.5	02:30	02:29	02:58	02:26	02:24	03:09	02:20	-4%
	J24 to J25	5.6	05:28	05:28	06:48	05:20	05:17	06:59	05:06	7%
	J25 to J26	3.6	03:30	03:33	03:56	03:29	03:30	03:58	03:21	1%
	J26 to J27	4.4	04:06	04:13	04:32	04:09	04:08	04:31	03:53	3%
	Total	16.1	15:33	15:42	18:14	15:24	15:19	18:36	14:40	3%
	% Change		0.8%	2.8%	7.5%	0.0%	0.7%	5.3%	0.9%	

Anticlockwise journey time comparison

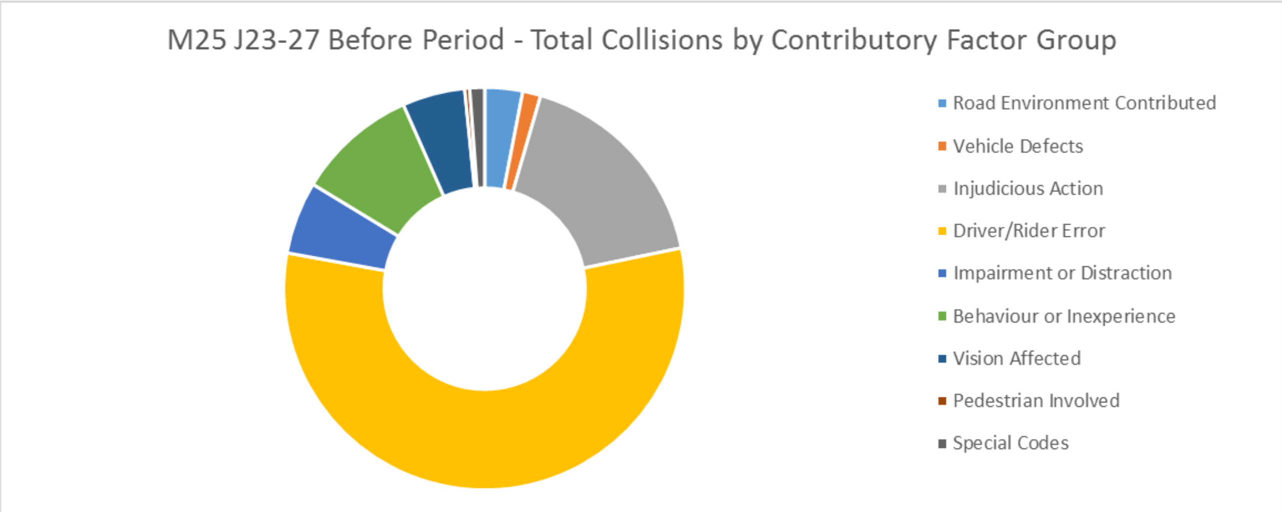
	Section	Distance (miles)	M-T AM	M-T IP	M-T PM	F AM	F IP	F PM	SS	Period average % change
Before	J27 to J26	2.5	05:37	04:03	04:09	04:21	04:12	04:06	03:54	
	J26 to J25	5.6	05:13	03:27	03:30	03:52	03:49	03:32	03:23	
	J25 to J24	3.6	06:47	05:25	05:39	06:07	05:47	05:40	05:20	
	J24 to J23	4.4	02:48	02:31	02:37	02:42	02:38	02:36	02:28	
	Total	16.1	20:25	15:27	15:55	17:02	16:27	15:55	15:05	
Yr2 After	J27 to J26	2.5	05:00	04:15	04:10	04:21	04:15	04:09	03:56	-1%
	J26 to J25	5.6	04:45	03:40	03:39	03:49	03:45	03:43	03:22	0%
	J25 to J24	3.6	06:24	05:39	05:40	05:53	05:36	05:40	05:18	-1%
	J24 to J23	4.4	03:14	02:30	02:32	02:55	02:34	02:35	02:21	2%
	Total	16.1	19:24	16:06	16:00	16:58	16:11	16:08	14:57	-0.5%
	% Change		-5.0%	4.2%	0.5%	-0.5%	-1.6%	1.3%	-0.8%	

Appendix C. Safety additional information

C.1. Contributory factors

Contributory factors by severity before period

Code	Contributory factor group	Fatal	Serious	Slight	Total
101-109	Road environment contributed	0	2	21	23
201-206	Vehicle defects	2	3	6	11
301-310	Injudicious action	0	7	123	130
401-410	Driver/rider error	8	41	374	423
501-510	Impairment or distraction	0	7	37	44
601-607	Behaviour or inexperience	1	5	67	73
701-710	Vision affected	0	3	35	38
801-810	Pedestrian involved	2	0	1	3
901-999	Special codes	0	1	8	9
Total		**13**	**69**	**672**	**754**



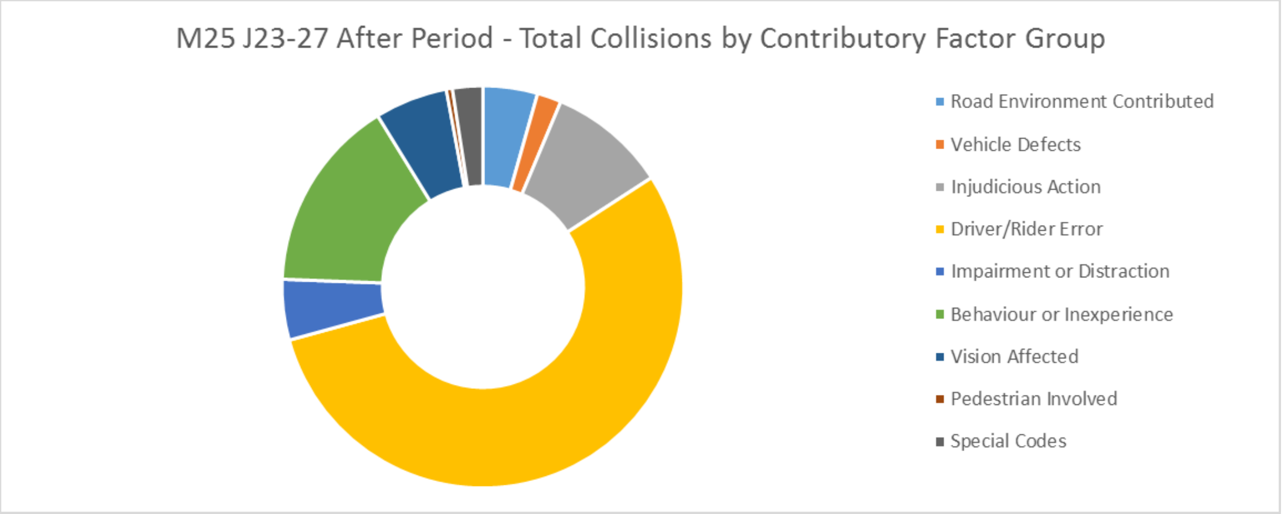
Rank	1 to 10
	11 to 15

Code	Contributory factors	Fatal	Serious	Slight	Total	Rank
Road environment contributed		**0**	**2**	**21**	**23**	
101	Poor or defective road surface	0	0	0	0	
102	Deposit on road (e.g. oil, mud, chippings)	0	0	1	1	34
103	Slippery road (due to weather)	0	2	15	17	11
104	Inadequate or masked signs or road markings	0	0	0	0	
105	Defective traffic signals	0	0	0	0	
106	Traffic calming (e.g. speed cushions, road humps, chicanes)	0	0	0	0	
107	Temporary road layout (e.g. contraflow)	0	0	0	0	
108	Road layout (e.g. bend, hill, narrow carriageway)	0	0	3	3	24
109	Animal or object in carriageway	0	0	2	2	28
Vehicle defects		**2**	**3**	**6**	**11**	
201	Tyres illegal, defective or under-inflated	0	1	2	3	24
202	Defective lights or indicators	0	0	0	0	
203	Defective brakes	1	0	1	2	28
204	Defective steering or suspension	1	0	1	2	28
205	Defective or missing mirrors	0	0	0	0	
206	Overloaded or poorly loaded vehicle or trailer	0	2	2	4	21
Injudicious action		**0**	**7**	**123**	**130**	
301	Disobeyed automatic traffic signal	0	0	0	0	
302	Disobeyed 'Give Way' or 'Stop' sign or markings	0	0	0	0	
303	Disobeyed double white lines	0	0	0	0	
304	Disobeyed pedestrian crossing facility	0	0	0	0	
305	Illegal turn or direction of travel	0	0	1	1	34
306	Exceeding speed limit	0	0	6	6	16
307	Travelling too fast for conditions	0	5	44	49	7
308	Following too close	0	2	72	74	3
309	Vehicle travelling along pavement	0	0	0	0	
310	Cyclist entering road from pavement	0	0	0	0	
Driver/rider error		**8**	**41**	**374**	**423**	
401	Junction overshoot	0	1	0	1	34
402	Junction restart (moving off at junction)	0	0	2	2	28
403	Poor turn or manoeuvre	2	4	37	43	8
404	Failed to signal or misleading signal	0	0	4	4	21
405	Failed to look properly	2	11	128	141	1
406	Failed to judge other person's path or speed	1	5	79	85	2
407	Passing too close to cyclist, horse rider or pedestrian	0	0	1	1	34
408	Sudden braking	1	5	57	63	4
409	Swerved	0	4	24	28	9
410	Loss of control	2	11	42	55	5
Impairment or distraction		**0**	**7**	**37**	**44**	
501	Impaired by alcohol	0	3	10	13	12
502	Impaired by drugs (illicit or medicinal)	0	0	0	0	
503	Fatigue	0	3	9	12	13
504	Uncorrected, defective eye sight	0	0	0	0	
505	Illness or disability, mental or physical	0	0	4	4	21
506	Not displaying lights at night or in poor visibility	0	0	0	0	
507	Cyclist wearing dark clothing at night	0	0	0	0	

508	Driver using mobile phone	0	0	0	0	
509	Distraction in vehicle	0	1	9	10	14
510	Distraction outside vehicle	0	0	5	5	20
Behaviour or inexperience		**1**	**5**	**67**	**73**	
601	Aggressive driving	0	0	6	6	16
602	Careless, reckless or in a hurry	1	4	48	53	**6**
603	Nervous, uncertain or panic	0	0	3	3	24
604	Driving too slow for conditions or slow vehicle (e.g. tractor)	0	1	0	1	34
605	Learner or inexperienced driver / rider	0	0	7	7	15
606	Inexperience of driving to the left	0	0	3	3	24
607	Unfamiliar with model of the vehicle	0	0	0	0	
Vision affected		**0**	**3**	**35**	**38**	
701	Stationary or parked vehicle(s)	0	0	0	0	
702	Vegetation	0	0	0	0	
703	Road layout (e.g. bend, winding road, hill crest)	0	0	0	0	
704	Buildings, road signs, street furniture	0	0	0	0	
705	Dazzling headlights	0	0	1	1	34
706	Dazzling sun	0	0	1	1	34
707	Rain, sleet, snow or fog	0	2	4	6	16
708	Spray from other vehicles	0	0	2	2	28
709	Visor or windscreen dirty or scratched	0	0	0	0	
710	Vehicle blind spot	0	1	27	28	**9**
Pedestrian involved		**2**	**0**	**1**	**3**	
801	Crossing road masked by stationary or parked vehicle	0	0	0	0	
802	Failed to look properly	0	0	1	1	34
803	Failed to judge vehicle's path or speed	0	0	0	0	
804	Wrong use of pedestrian crossing facility	0	0	0	0	
805	Dangerous action in carriageway (e.g. playing)	1	0	0	1	34
806	Impaired by alcohol	0	0	0	0	
807	Impaired by drugs (illicit or medicinal)	0	0	0	0	
808	Careless, reckless or in a hurry	1	0	0	1	34
809	Pedestrian wearing dark clothing at night	0	0	0	0	
810	Disability or illness, mental or physical	0	0	0	0	
Special codes		**0**	**1**	**8**	**9**	
901	Stolen vehicle	0	0	0	0	
902	Vehicle in course of crime	0	0	1	1	34
903	Emergency vehicle on a call	0	0	2	2	28
904	Vehicle door opened or closed negligently	0	0	0	0	
999	Other	0	1	5	6	16

Contributory factors by severity after period

Code	Contributory factor group	Fatal	Serious	Slight	Total
101-109	Road environment contributed	0	0	18	18
201-206	Vehicle defects	0	1	7	8
301-310	Injudicious action	0	3	36	39
401-410	Driver/rider error	2	10	213	225
501-510	Impairment or distraction	0	4	16	20
601-607	Behaviour or inexperience	1	2	61	64
701-710	Vision affected	0	2	22	24
801-810	Pedestrian involved	2	0	0	2
901-999	Special codes	0	0	10	10
Total		**5**	**22**	**383**	**410**



Rank	1 to 10
	11 to 15

Code	Contributory factors	Fatal	Serious	Slight	Total	Rank
Road environment contributed		**0**	**0**	**18**	**18**	
101	Poor or defective road surface	0	0	1	1	25
102	Deposit on road (e.g. oil, mud, chippings)	0	0	2	2	21
103	Slippery road (due to weather)	0	0	12	12	10
104	Inadequate or masked signs or road markings	0	0	0	0	
105	Defective traffic signals	0	0	1	1	25
106	Traffic calming (e.g. speed cushions, road humps, chicanes)	0	0	0	0	
107	Temporary road layout (e.g. contraflow)	0	0	0	0	
108	Road layout (e.g. bend, hill, narrow carriageway)	0	0	1	1	25
109	Animal or object in carriageway	0	0	1	1	25
Vehicle defects		**0**	**1**	**7**	**8**	
201	Tyres illegal, defective or under-inflated	0	0	2	2	21
202	Defective lights or indicators	0	0	0	0	
203	Defective brakes	0	0	1	1	25
204	Defective steering or suspension	0	1	3	4	16
205	Defective or missing mirrors	0	0	0	0	
206	Overloaded or poorly loaded vehicle or trailer	0	0	1	1	25
Injudicious action		**0**	**3**	**36**	**39**	
301	Disobeyed automatic traffic signal	0	0	0	0	
302	Disobeyed 'Give Way' or 'Stop' sign or markings	0	0	0	0	
303	Disobeyed double white lines	0	0	0	0	
304	Disobeyed pedestrian crossing facility	0	0	0	0	
305	Illegal turn or direction of travel	0	0	0	0	
306	Exceeding speed limit	0	0	4	4	16
307	Travelling too fast for conditions	0	0	10	10	11
308	Following too close	0	3	22	25	6
309	Vehicle travelling along pavement	0	0	0	0	
310	Cyclist entering road from pavement	0	0	0	0	
Driver/rider error		**2**	**10**	**213**	**225**	
401	Junction overshoot	0	0	0	0	
402	Junction restart (moving off at junction)	0	0	0	0	
403	Poor turn or manoeuvre	0	1	26	27	4
404	Failed to signal or misleading signal	0	0	0	0	
405	Failed to look properly	1	7	72	80	1
406	Failed to judge other person's path or speed	1	0	52	53	2
407	Passing too close to cyclist, horse rider or pedestrian	0	0	0	0	
408	Sudden braking	0	2	23	25	6
409	Swerved	0	0	13	13	9
410	Loss of control	0	0	27	27	4
Impairment or distraction		**0**	**4**	**16**	**20**	
501	Impaired by alcohol	0	1	1	2	21
502	Impaired by drugs (illicit or medicinal)	0	0	0	0	
503	Fatigue	0	1	3	4	16
504	Uncorrected, defective eye sight	0	0	0	0	
505	Illness or disability, mental or physical	0	1	5	6	13
506	Not displaying lights at night or in poor visibility	0	0	0	0	
507	Cyclist wearing dark clothing at night	0	0	0	0	

508	Driver using mobile phone	0	0	1	1	25
509	Distraction in vehicle	0	1	4	5	15
510	Distraction outside vehicle	0	0	2	2	21
Behaviour or inexperience		**1**	**2**	**61**	**64**	
601	Aggressive driving	0	1	5	6	13
602	Careless, reckless or in a hurry	1	1	46	48	**3**
603	Nervous, uncertain or panic	0	0	4	4	16
604	Driving too slow for conditions or slow vehicle (e.g. tractor)	0	0	1	1	25
605	Learner or inexperienced driver / rider	0	0	4	4	16
606	Inexperience of driving to the left	0	0	0	0	
607	Unfamiliar with model of the vehicle	0	0	1	1	25
Vision affected		**0**	**2**	**22**	**24**	
701	Stationary or parked vehicle(s)	0	0	0	0	
702	Vegetation	0	0	0	0	
703	Road layout (e.g. bend, winding road, hill crest)	0	0	1	1	25
704	Buildings, road signs, street furniture	0	0	0	0	
705	Dazzling headlights	0	0	0	0	
706	Dazzling sun	0	0	0	0	
707	Rain, sleet, snow or fog	0	0	1	1	25
708	Spray from other vehicles	0	0	1	1	25
709	Visor or windscreen dirty or scratched	0	0	0	0	
710	Vehicle blind spot	0	2	19	21	**8**
Pedestrian involved		**2**	**0**	**0**	**2**	
801	Crossing road masked by stationary or parked vehicle	0	0	0	0	
802	Failed to look properly	0	0	0	0	
803	Failed to judge vehicle's path or speed	0	0	0	0	
804	Wrong use of pedestrian crossing facility	0	0	0	0	
805	Dangerous action in carriageway (e.g. playing)	1	0	0	1	25
806	Impaired by alcohol	0	0	0	0	
807	Impaired by drugs (illicit or medicinal)	0	0	0	0	
808	Careless, reckless or in a hurry	1	0	0	1	25
809	Pedestrian wearing dark clothing at night	0	0	0	0	
810	Disability or illness, mental or physical	0	0	0	0	
Special codes		**0**	**0**	**10**	**10**	
901	Stolen vehicle	0	0	0	0	
902	Vehicle in course of crime	0	0	0	0	
903	Emergency vehicle on a call	0	0	1	1	25
904	Vehicle door opened or closed negligently	0	0	0	0	
999	Other	0	0	9	9	12

C.2. Red X compliance

Table C-1 Summary of Red X events

Duration (mins)	Total number of non-compliant vehicles	Per-lane average minutely flow during lane closure	Average minutely flow of non-compliant vehicles	Percentage non-compliance
24	29	19	1	2%
20	92	19	5	8%
6	18	17	3	4%
6	7	14	1	2%
25	56	17	2	3%
11	1	4	0	1%
10	18	16	2	3%
5	1	4	0	2%
2	9	11	4	10%
17	24	11	1	3%
20	22	17	1	2%
7	18	12	2	5%
7	9	18	1	2%
32	126	22	4	4%
2	2	4	1	6%
64	55	3	1	6%
8	14	7	2	6%
28	103	15	4	6%
40	205	16	5	8%
20	27	9	1	4%
Average: 18	Average: 42	Average: 13	Average: 2	Average: 4%